ACKNOWLEDGMENTS

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UNITED STATES DEPARTMENT OF THE INTERIOR

Fisheries Assistance Office
U.S. Fish and Wildlife Service
Vancouver, Washington

INSTREAM FLOW STUDY

OF THE

WARM SPRINGS RIVER

Prepared by: Brian C. Cates

Fishery Management Biologist

A Cooperative Study By:

U.S. Fish and Wildlife Service

and

Columbia River Inter-Tribal Fish Commission

SEPTEMBER, 1981

(Funded by the Bonneville Power Administration)

INTRODUCTION

The anadromous fish runs into the Deschutes River and its tributaries have historically been of great importance to the Indian people of central Oregon. The Confederated Tribes of the Warm Springs Indian Reservation are especially concerned about the anadromous fish runs entering the waters of the Reservation and are interested in the enhancement and protection of this resource. Because of this concern, the U.S. Fish and Wildlife Service (USFWS) and the Columbia River Inter-Tribal Fish Commission (CRITFC) requested funding from the Bonneville Power Administration (BPA) to conduct an instream flow study on the Warm Springs Indian Reservation. The object of the study is to determine the suitability of the area for different anadromous fish species, and to serve as a guide for the determination of methods of enhancing the desired runs. Funding was received in October 1979. Field work began in October 1979 and continued through October 1980. Most of the field measurements were obtained by the U.S. Geological Survey (USGS) through a contract agreement with the USFWS. The study was conducted by the USFWS Fisheries Assistance Office-Vancouver (FAO) and consisted of the analysis of available habitat under varying instream flow regimes using the incremental methodology developed by the USFWS Instream Flow Group (IFG) in Fort Collins, Colorado. This report describes available anadromous fish habitat in the Warm Springs River and its tributaries under varying flow conditions.

SITE SELECTION

The initial step in the selection of the study areas was the stratification of the stream into large homogenous sections. This delineation of homogenous sections was accomplished according to IFG instructions by using such factors as topography, geology, gradient, stream flow, biological communities, and certain man-made conditions such as channelization. This task was completed by using a combination of maps, a tour of the area, and consultations with Tribal Natural Resources personnel.

Once the homogenous sections were established, each section was surveyed visually to obtain general information on habitat types and determine accessibility to field crews. A concensus of opinion between the consultants and the USFWS biologist was then used to select the study reach that best represented the stream section. The typical study reach contained two riffle-pool, or meander crossing meander-pool sequences and averaged ten to fourteen times the average channel width, as recommended by the IFG (Bovee and Milhous, 1978).

One representative reach was established in each homogenous section. Table 1 describes the homogenous sections and locates the study reaches. Figure 1 shows the location of the study reaches within the Warm Springs River drainage.

On each study reach, transects were positioned across the stream to describe habitat types. Whenever possible the downstream transect, as specified by the IFG methodology, was placed on a hydraulic control. Between three and eight transects were placed in each reach depending on its complexity.

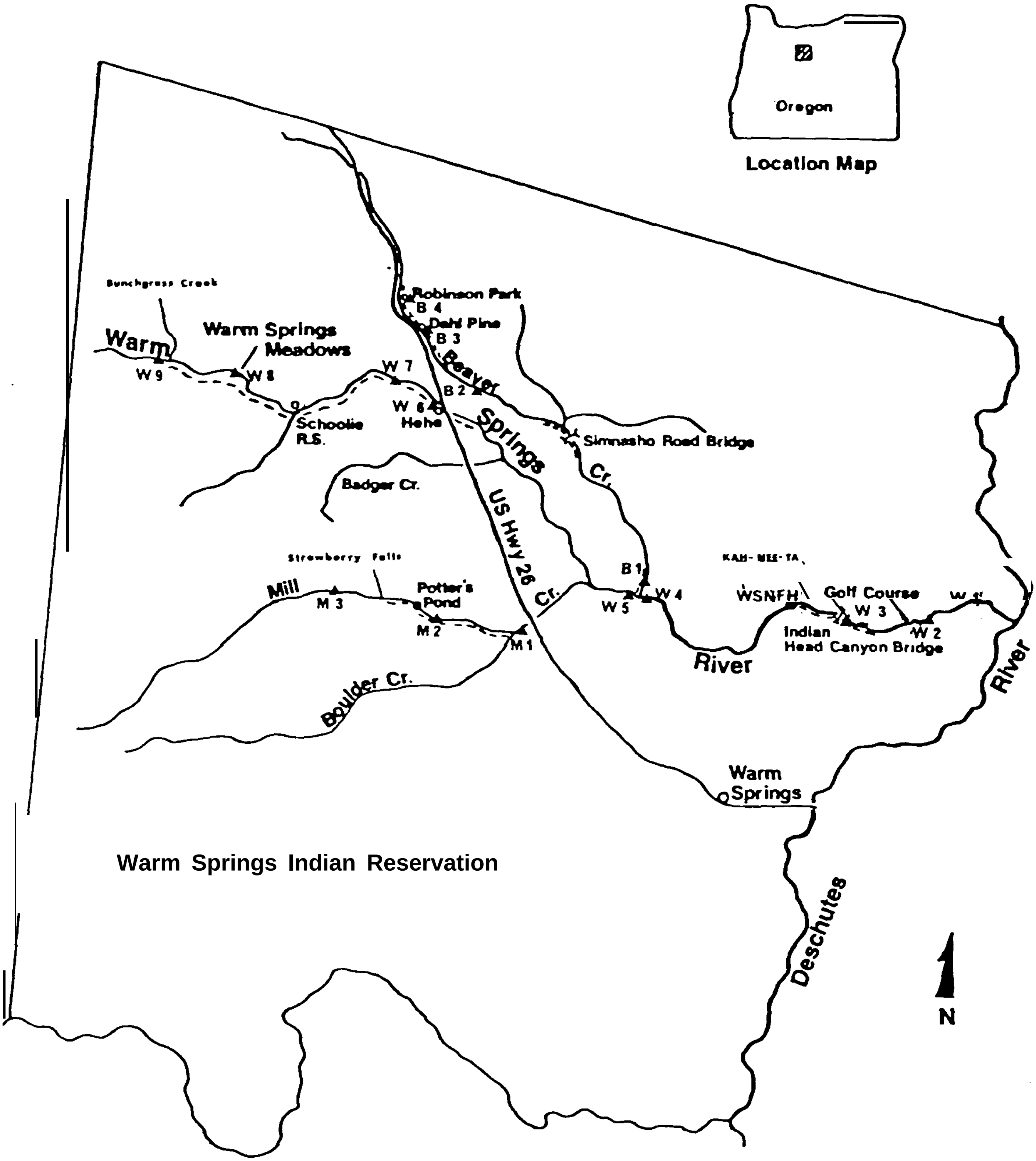
Table 1. Homogenous Section Boundaries and Study Reach Locations.

Warm Springs River

Homogenous Section Boundaries	Study Reach Location	Stream Characteristics
Mouth of Warm Springs River to Island 1.6 miles upstream; length 1.6 miles.	W-l .9 miles above mouth.	Low stream gradient with relatively slow flowing waters short riffles and long pools.
Island 1.6 miles above mouth to just below Kah-Nee-Ta village: length 5.9 miles.	W-Z Just above USGS stream gage 4.6 miles above mouth.	Low stream gradient with short riffles and long slow flowing pools.
Just below Kah-Nee-Ta village to Warm Springs NFH; length 2.9 miles.	W-3 .1 mile below Indian Head Bridge.	Low stream gradient in narrowing canyon.
Just above Warm Springs NFH to confluence of Beaver Creek; length 10 miles.	w-4 .1 mile below confluence of Beaver Creek.	Moderate stream gradient in deep, narrow canyon.
Confluence of Beaver Creek to 1.8 miles below Highway 26 bridge; length 9.5 miles.	W-5 .1 mile above confluence of Beaver Creek.	Moderate stream gradient in deep, narrow canyon.
1.8 miles below Highway 26 bridge to 1 mile above Highway 26 bridge; lenqth 2.8 miles.	W-6 Just below rodeo grounds bridge at Hehe.	Low stream gradient in relatively flat timbered areas.
1 mile above Highway 26 bridge to Schoolie; length 6.8 miles.	w-7 1.5 miles above Hehe.	Low to moderate stream gradient in shallow, timbered canyon.
Schoolie Ranger Station to .9 miles below Bunchgrass Creek; length 2.7 miles.	W-8 1.2 miles above Schoolie.	Low gradient meander-stream in alpine meadow swamp area.
.9 miles below confluence of Bunchgrass Creek to .5 miles above bridge on Road W-240; lenqth 2.0 miles.	w-9 .3 miles above confluence with Bunchgrass Creek.	Moderate to high gradient stream in timbered canyon.

Tributary Streams

Homogenous Section Boundaries	Study Reach Location	Stream Characteristics
Beaver Creek from .3 miles above confluence with Warm Springs River to 1.3 miles above mouth; length 1 mile.	B-l .5 miles above confluence with Warm Springs River.	Low gradient meandering stream in wide canyon.
1.3 miles above mouth to where Beaver Creek meets Highway 26, 10.7 miles above the mouth; length 9.4 miles.	B-2 3.1 miles above Simnasho Bridge.	Moderate gradient stream in wooded canyon becoming sparsely timbered in lower reaches.
.5 miles below Dahl Pine bridge to .3 miles below Robinson Park; length 3.1 miles.	B-3 .5 miles above Dahl Pine bridge.	Low gradient stream meandering through meadow-timbered areas.
.3 miles below Robinson Park bridge to 4.0 miles above bridge; length 4.3 miles.	B-4 50 yards above Robinson Park bridge.	Moderate gradient stream paralleling highway.
Mill Creek mouth to confluence of Boulder Creek; length 3.6 miles.	M-l Just below confluence of Boulder Creek.	Moderate to high gradient stream in steep timbered canyon.
Mill Creek from confluence of Boulder Creek to Potter's Pond; lenqth 1.6 miles.	M-2 .5 miles below Potter's Pond.	Moderate gradient stream in gradually deepening canyon.
Potter's Pond to 6.7 miles upstream; length 6.7 miles.	M-3 Old Mill Camp 4.0 miles above Potter's Pond.	Moderate to high gradient stream in timbered canyon.



Areas of Observed Spawning Activity: – – – –

Study Reach Locations: A

Figure 1. Warm Springs River drainage and study reach locations.

DATA COLLECTION

As suggested by IFG, stream parameters were measured at high, medium, and low flows. Using the three-point rating curve approach increases the reliability of velocity and water surface elevation predictions made from the data. The three-point approach also allows for measurement of statistical error in fitting the instream flow model; and generally allowed a useful range of extrapolation of 0.4 times the minimum discharge measured to 2.5 times the maximum discharge measured.

The actual field measurements were made according to the methods described by Bovee and Milhous (1978). The elevation of the ground and headstakes marking the transect ends and the distance between the transects was obtained prior to the collection of flow measurements. For each flow measured, the water surface elevation was determined by measuring the difference in elevation between the headstake and the water surface at each transect. A tagline was stretched across the stream at each transect to measure the distance between each velocity measuring point and the bank headstake. Measurements of depth, velocity and substrate were taken along each transect at the predetermined points. The number of measurement points on a transect varied but was usually between 20 and 30. Discharges were measured at one transect per reach. IFG recommends that at least 20 measurement points be placed on the discharge transect to assure that no more than five percent of the stream discharge was represented by any one data point. The velocity at each point was measured using either a Price or Pigmy current meter. For depths of less than 2.5 feet, one measurement of velocity, taken at six tenths of the depth from the surface, was used to determine the mean column velocity. For depths greater than 2.5 feet, two measurements of velocity were taken, one at two tenths and one at eight tenths of the depth from the surface. The two velocity measurements were then averaged to obtain the mean velocity. The streambed elevation was determined by subtracting the water depth from the water surface elevation.

Substrate was examined and characterized, based on a modified Wentworth scale. This scale, based on particle size, assigns a numerical rating between one and eight to substrate type (Table 2).

Table 2. Substrate Classification Based Upon Modified Wentworth Scale.

Substrate Index	Material	Size Range (inn)
8	Bedrock	--
7	Boulder	>305
6	Cobble	75 - 305
5	Gravel	5 - 75
4	Sand	.125 - 5
3	Silt	.062 - .125
2	Clay	<.062
1	Plant Detritus	--

The high and medium discharge measurements were taken during the period March through June. Low flow measurements were taken between August and November.

COMPUTER ANALYSIS

The IFG process of evaluating instream flow requirements for any species of fish is composed of two segments: hydraulic simulation, and habitat evaluation. Hydraulic simulation estimates the relationship of one or more sets of measured flow related parameters to stream discharge. Habitat evaluation estimates the total available habitat, by species and life history stage, based on the results of hydraulic simulation.

Fisheries Assistance Office staff, simulated six to twelve discharges for each river reach, using the IFG's rating curve hydraulic simulation model (IFG4).

Calibration of the hydraulic simulation model was performed using an allowable error criterion of one plus or minus 10% in the velocity adjustment factors, for all simulated discharges.

After completion of hydraulic simulation, the resultant prediction of hydraulic conditions were interfaced with the habitat (IFG3) program to obtain estimates of available habitat at various stream discharges. Probability of use curves for depth, velocity, and substrate make up the core of the IFG's Habitat model (Figure 2).

The probability of use curves were developed by IFG, based on the best available information for each species. Frequency of occurrence was related to increments of depth, velocity, and substrate. Probability of use was then equated with frequency of occurrence. The point with the greatest frequency of occurrence was assigned 1.0 probability of use. Where frequency of use equaled zero, probability of use was assigned zero. Intermediate values were assigned on a linear scale basis. When frequency of occurrence data was not available literature was searched by IFG to develop curves based on such things as range and optimum conditions (where a species may be found), parameter overlaps (presence-absence information), and indirect parameter analyses. Bovee (1977) describes in detail how each of these methods are used to construct probability curves and the reliability of each curve.

In order to estimate the composite probability of use, the IFG3 program cross-multiplies the individual probabilities drawn from the depth, velocity and substrate curves. The program applies this process to data collected from each point across all transects. The next step expands the habitat rating given to the individual data points to the total habitat contained within the study reach. Transects are divided into segments centered about a data point. For the transects forming the upper and lower boundaries of a reach, the length of the segments extend from the transect to a line one-half the distance to the next transect. Segments of the inside transects extend one-half the distance from the transect in each direction. The entire area of each segment is given a habitat value the same as its central data point located on this transect (Figure 3).

FALL CHINOOK

SPAWNING

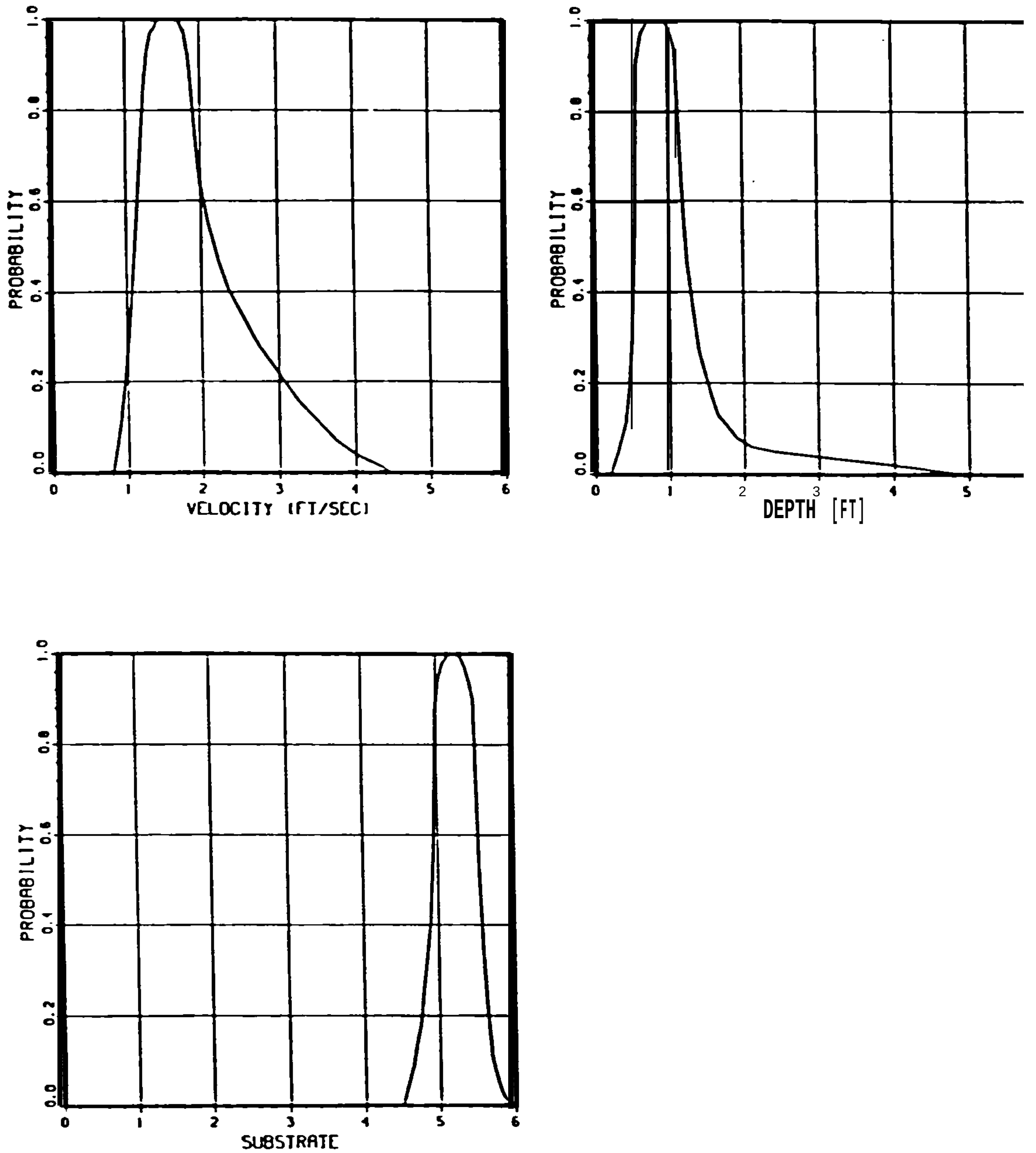
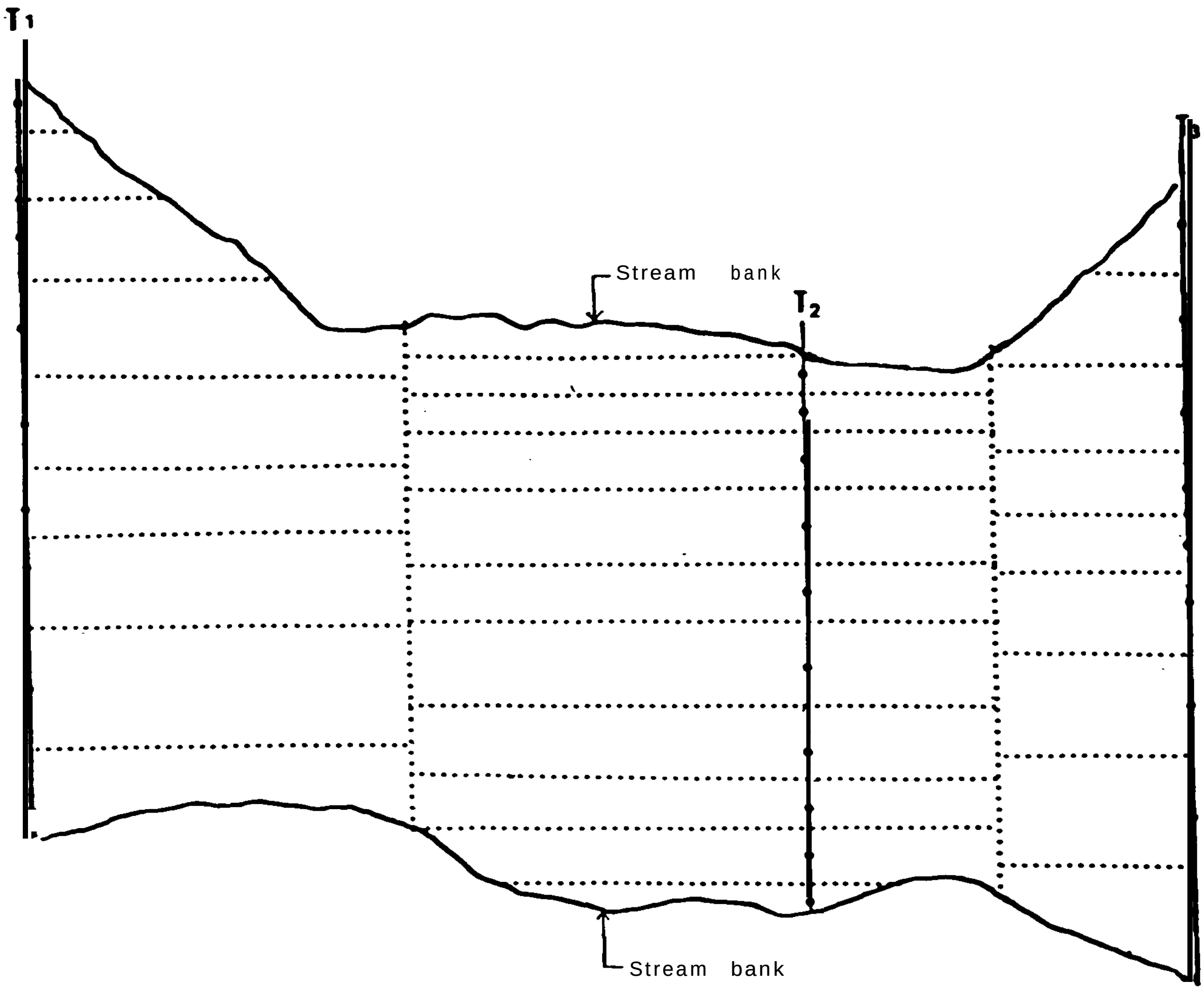


Figure 2: Probability of Use Curves.



Ti-Transect
• - Data measurement point
····–1/2 Distance between Transect or
Data measurement point

Figure 3: Example of the Division of a Study Reach into Segments to Estimate Habitat Value.

To compute available habitat, the area of the segment containing the data point is multiplied by the composite probability of use. This results in an estimate of available habitat expressed as weighted usable area. One unit of weighted usable area is equivalent to a unit of optimum habitat. The IFG3 program standardizes the measure of available habitat by expressing it in square feet of weighted usable area per 1,000 lineal feet of stream.

FACTORS EFFECTING PREDICTION OF HABITAT

Anadromous fish production is greatly influenced by water temperature. IFG has developed a probability of use curve for temperature as it relates to the various anadromous species. Figure 4 illustrates the probability of use curve for temperature as it effects juvenile steelhead rearing. This curve indicates that at temperatures higher than 24.4°C (76°F) the probability of use for juvenile steelhead rearing drops to zero. Maximum daily water temperature in the lower Warm Springs River occasionally exceeds 21.1°C (70°F) during the summer months. The temperatures in the upper reaches of the Warm Springs River are much cooler and remain in the 40°-50° range much of the year. Maximum daily temperature during late summer in the Schoolie area generally ranges between 50° and 56°f. Late summer water temperatures in lower Beaver Creek approach 70°F. Mill Creek temperatures near Potters Pond appear to be several degrees cooler than that seen at the mouth of Beaver Creek.

The probability of use curves developed by IFG are based on the hydraulic prediction of mean column velocity. At high flows the mean column velocity can be significantly higher than velocities occurring near the streambed where juvenile salmonids would be expected to occur. In this case the model probably underestimates the actual available habitat at high flows. This would be especially pronounced in areas where the mean water column velocities exceed the tolerance range identified in the probability of use curves.

The IFG velocity model also tapers off all velocity curves so as to end at the origin. Interpretation of this would suggest that salmonids do not utilize zero velocity areas. It has been amply demonstrated that salmonids will utilize these areas to some extent. The model does not take this into account and as a result will slightly underestimate available habitat.

Instream and overhead cover are additional factors that influence the suitability of streams for anadromous fish. While cover analysis would provide additional input into the model it is felt that in the case of the Warm Springs River system, cover is not among the most critical factors influencing anadromous fish production.

Evidence, asknowledged by IFG (Bovee, 1978), indicates that depth probability of use curves do not tail off for fry and juvenile steelhead at depths greater than 1.5 feet (juvenile curve) and 0.5 feet (fry curve)

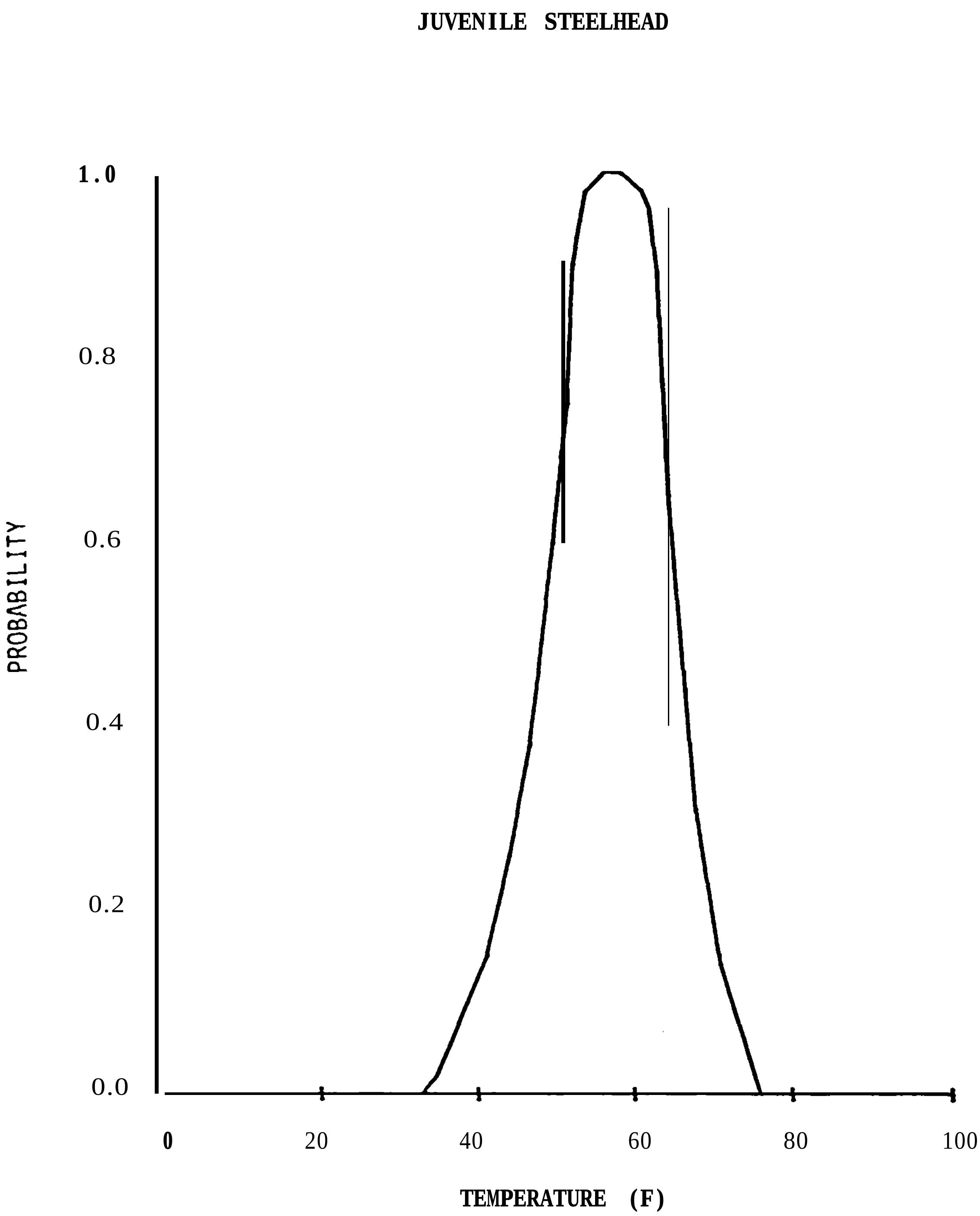


Figure 4: Probability of Use Curve for Temperature.

utilized in the present model. It is reasonable to assume that this same lack of tailing off would also occur in depth probability of use curves for other anadromous salmonid fry and juveniles. Fish and Wildlife Service personnel in the Arcata Fisheries Assistance Office evaluated several stream sections with and without the tailing effect of the probability of use curves. The tests showed insignificant differences in prediction of available habitat throughout the ranges tested (Anonymous, 1981 Instream Flow Study of the Umatilla River). Consequently, although the curves used in this study for juvenile and fry may not reflect true behavior at these life stages, we do not feel their use significantly effected the results of the study.

OUTPUT

For each study reach, the amount of available habitat for the range of flows modeled is provided in graphic and tabular form by species and life history stage.

Mean monthly discharges in the Warm Springs system were obtained from the U.S. Geological Survey at a point just below study reach W-2. Discharge records have been recorded there since October 1972. Flow records are not available for other areas in the system, but the discharges in the upper drainage probably don't vary as much because of the constant flow of the various feeder springs. Figure 5 illustrates the mean monthly discharges noted at the USGS recording station.

Steelhead, coho, and spring chinook salmon are the only anadromous fish utilizing the Warm Springs system at the present time, however the potential habitat for fall chinook was also investigated in this report.

Probability of use curves were not available for summer steelhead which are present in the Warm Springs system. Curves for winter steelhead were utilized for the purposes of this report. Past observations at WSNFH indicate that most summer steelhead probably do not enter the stream until February, and continue arriving until May. Adult steelhead do not appear to be holding for any prolonged length of time prior to spawning.

The optimum flow for a given lifestage is the discharge at which the weighted usable area attains its maximum value. In several instances, available habitat was increasing at the end of the range of discharges that could be modeled within the 10% velocity adjustment factor. Optimum discharge in these instances was selected as the last discharge modeled.

By comparing the figures and tables in each section, the user of this report can determine the extent or degree of impact an altered flow regime would have on anadromous fish habitat. In addition it will give an indication of the suitability of the system to each particular species. As a result of this study, the resource manager will have a tool that will assist in comparing various water management alternatives for the Warm Springs Reservation and their effect on the anadromous fish resource.

The following section provides the habitat data for each study reach beginning near the mouth of the Warm Springs River and proceeding upstream, including the two major tributaries, Beaver and Mill Creeks.

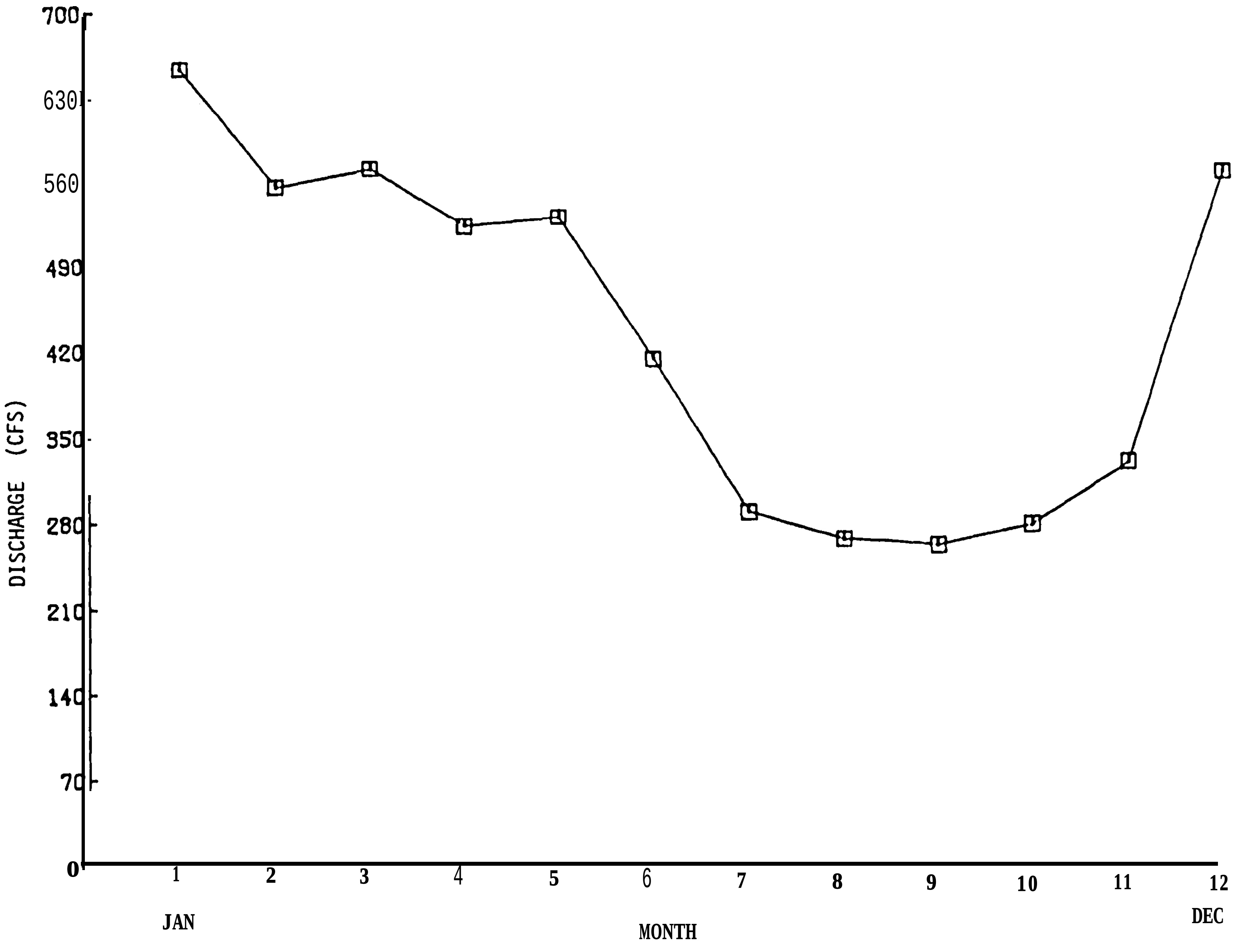
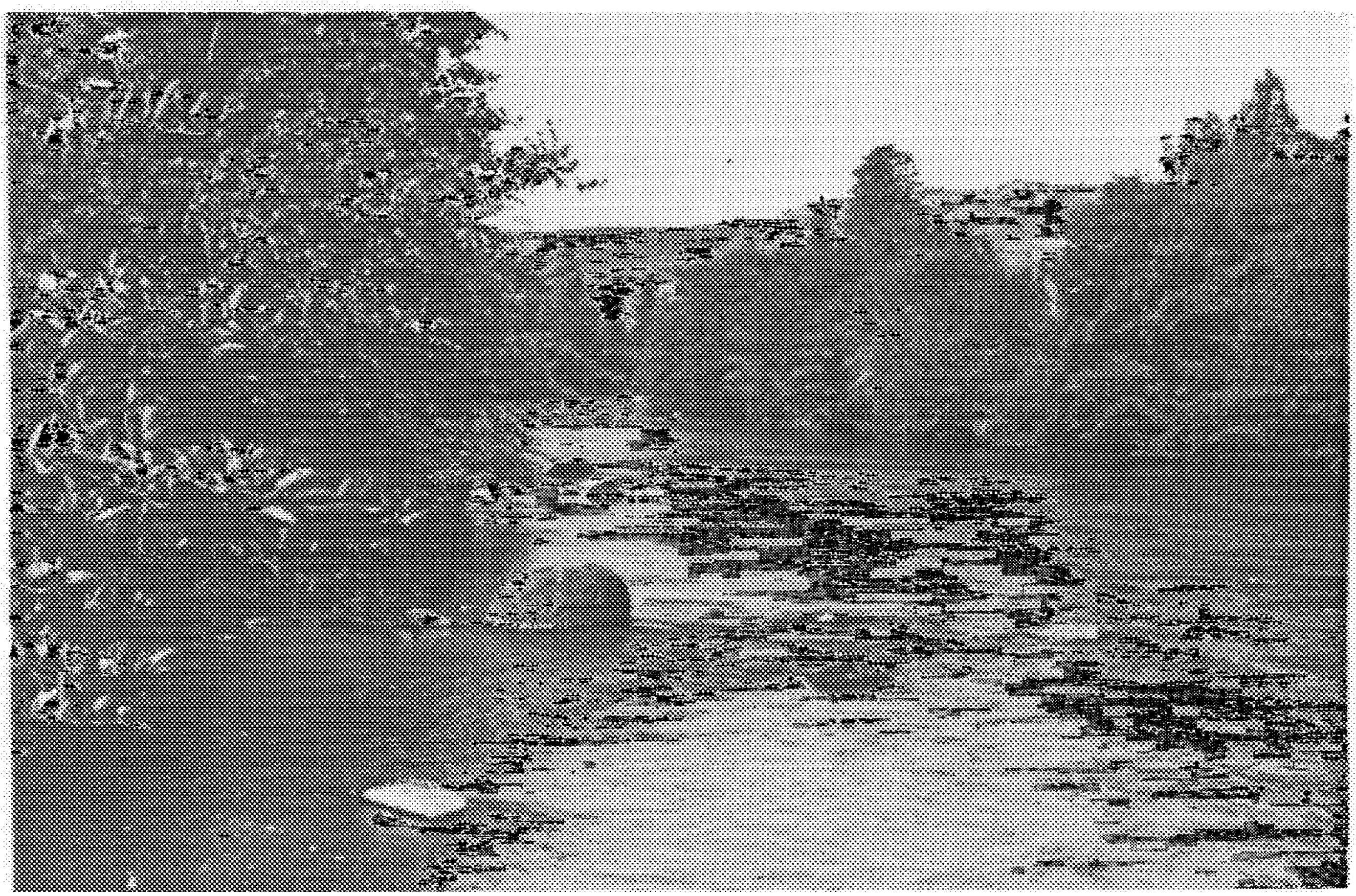
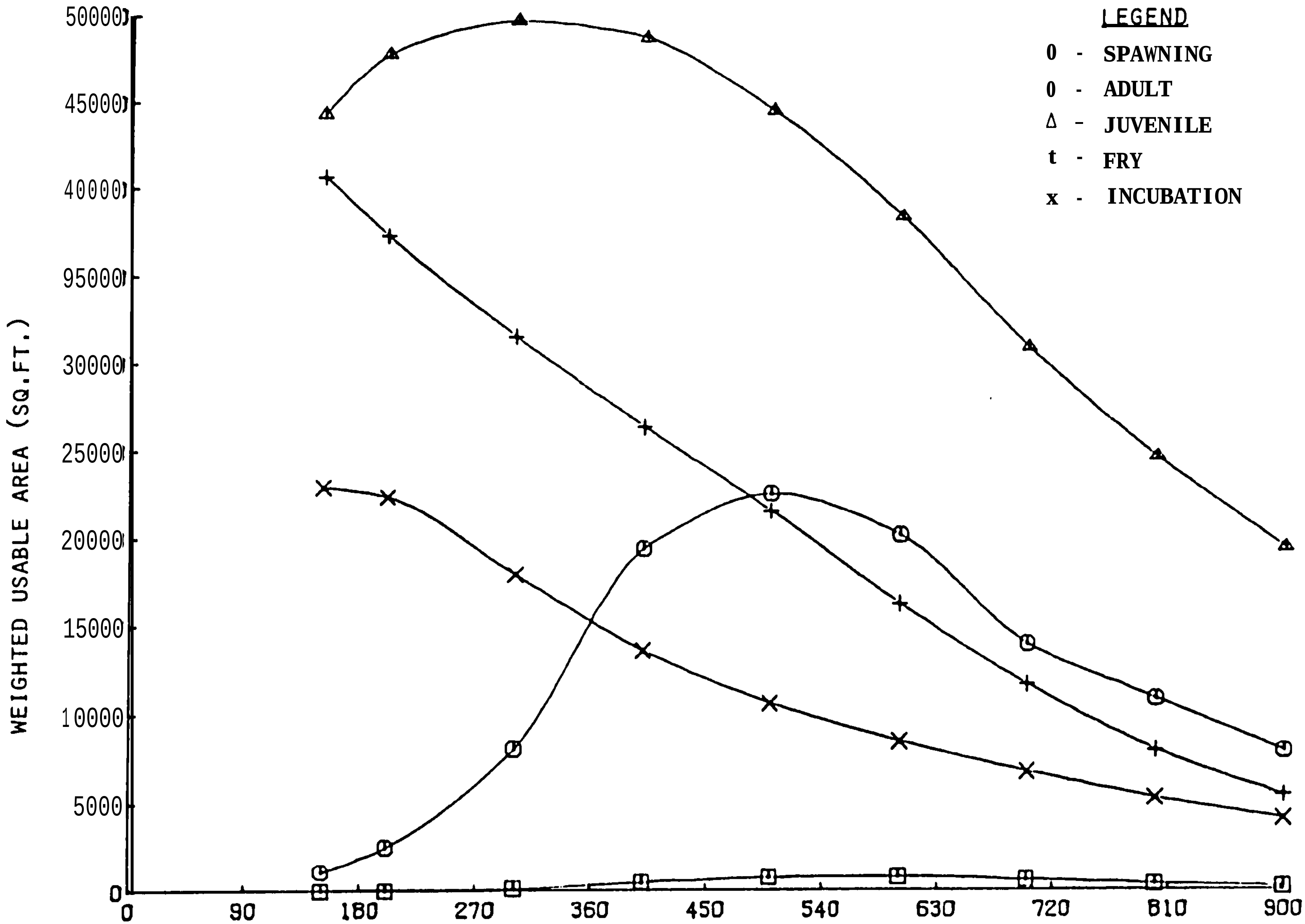


figure 5. Mean monthly discharge measured in the Warm Springs River below Kah-Nee-Ta (1972-1980).

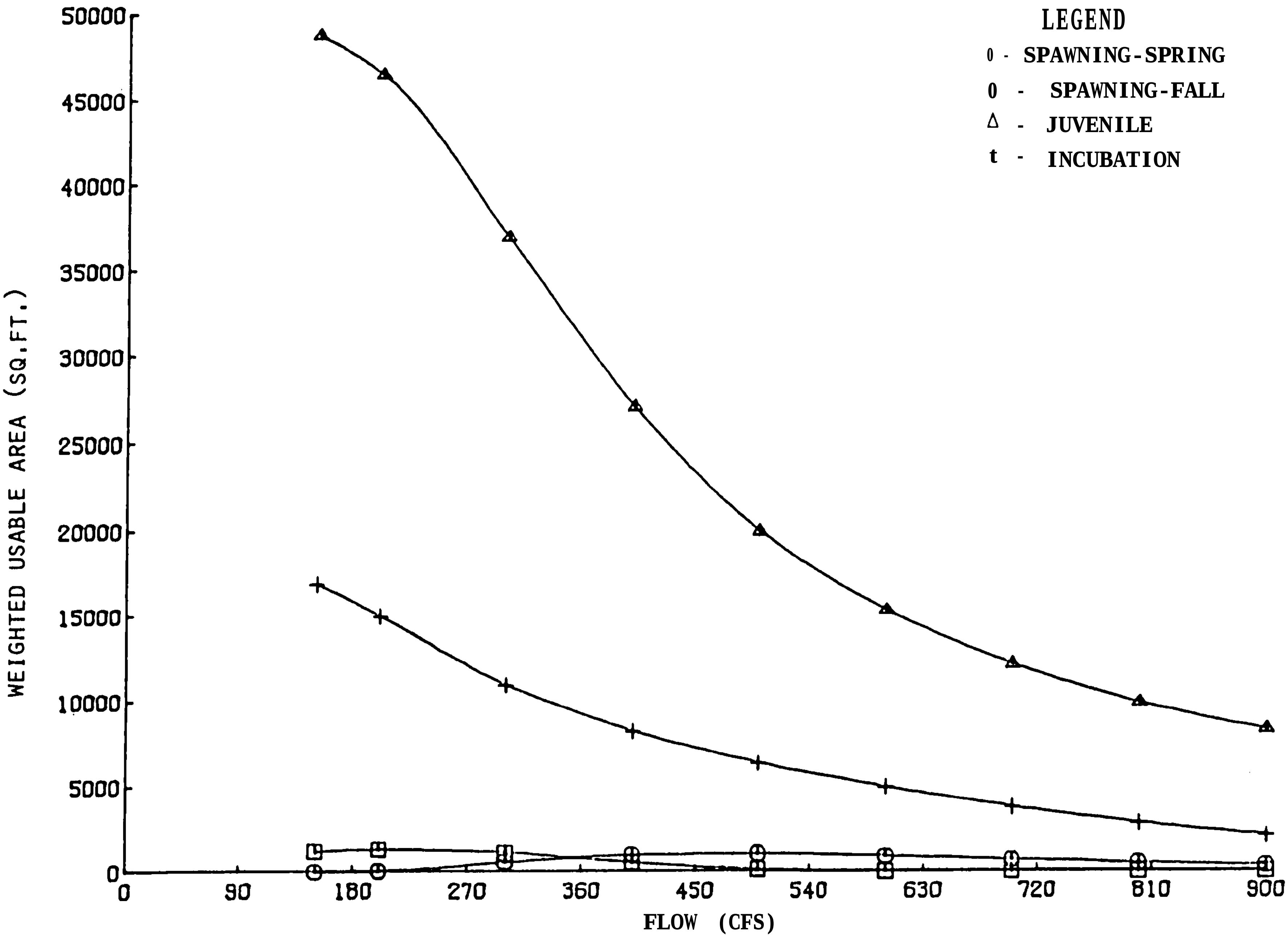


WARM SPRINGS RIVER W-1



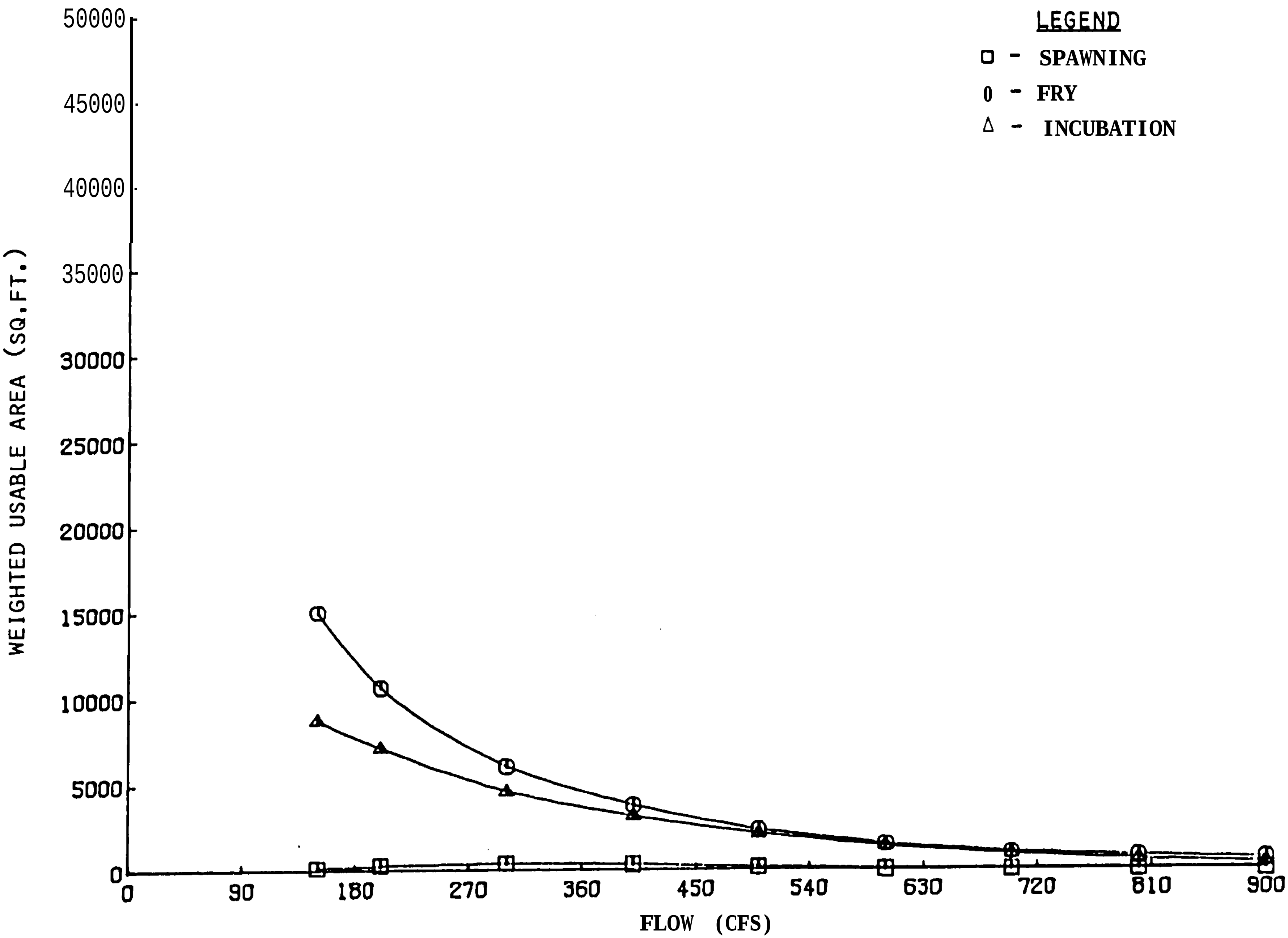
WARM SPRINGS RIVER W-1

STEELHEAD (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-l

CHINOOK SALMON (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-1

COHO SALMON (CLEARWATER, S = ,004)

WARM SPRINGS RIVER (W-1)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 1,000 FEET OF STREAM

STEELHEAD

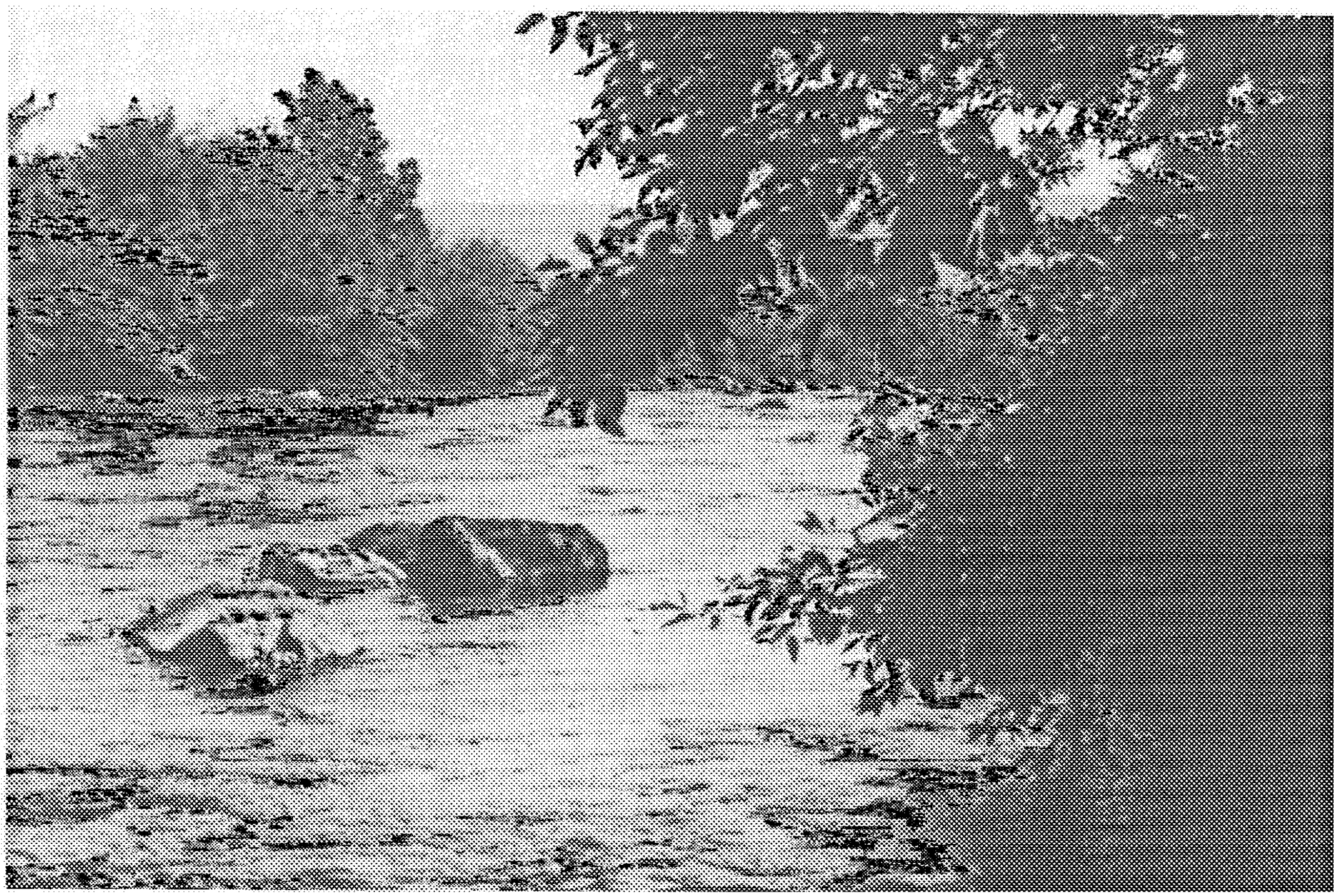
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
150	0	1113	44385	40748	22994
200	0	2493	47835	37353	22434
300	141	8112	49735	31627	18014
400	514	19492	48749	26489	13665
500	784	22632	44570	21613	10657
600	809	20249	38418	16320	8491
700	615	14025	30999	11720	6769
800	403	10911	24712	7998	5301
900	258	7936	19501	5467	4114

CHINOOK SALMON

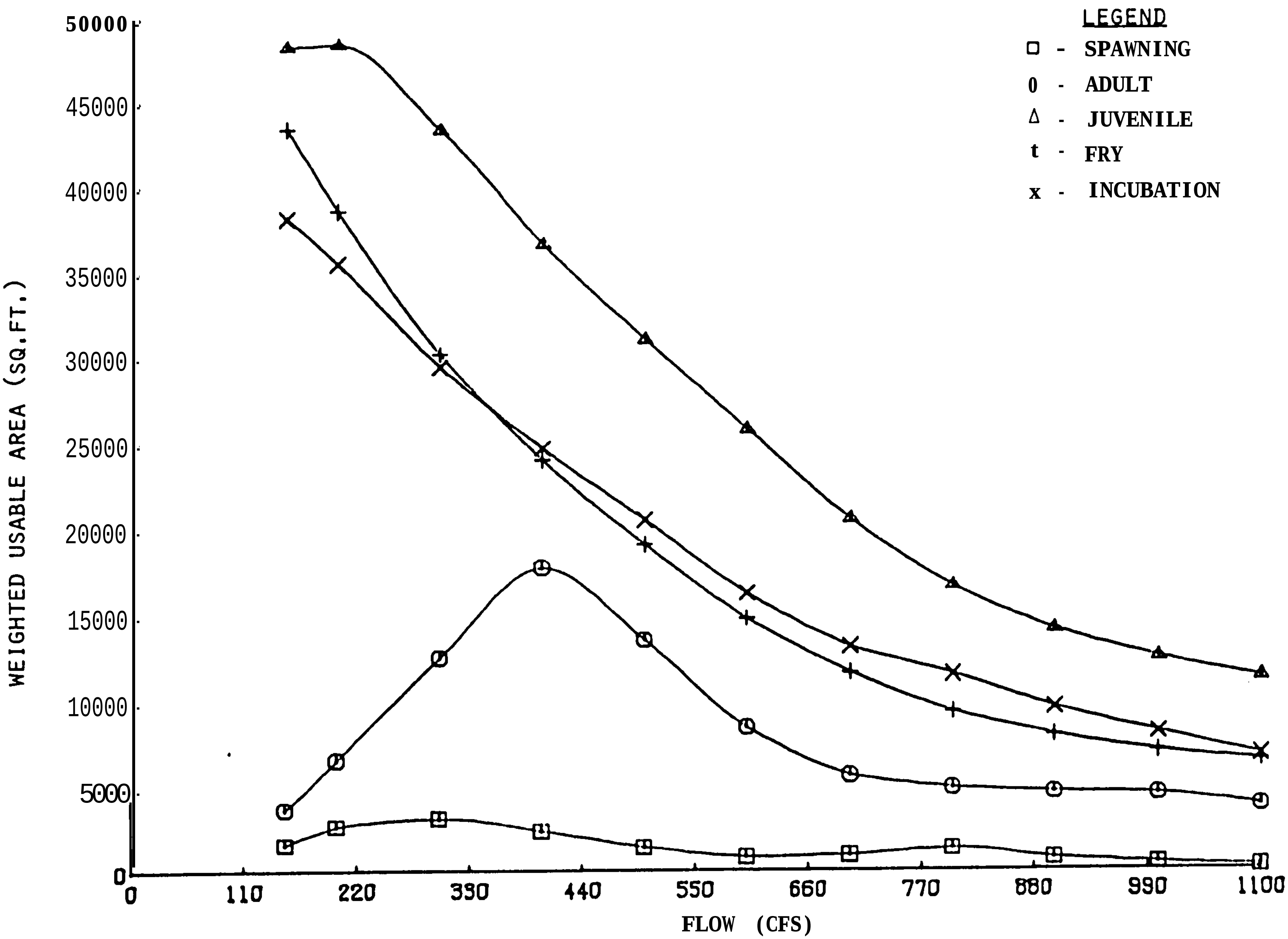
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
150	1217	0	48791	16888
200		67	46519	15007
300	1344	586	36950	10952
400	541	1007	27118	8249
500	120	1061	19966	6363
600	0	902	15264	4946
700	0	686	12105	3787
800	0	483	9819	2826
900	0	352	8246	2109

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
150	202	15020	8764
200	325	10685	7174
300	437	6102	4636
400	363	3805	3155
500	179	2338	2099
600	36	1480	1348
700	0	1002	881
800	0	745	551
900	0	609	338

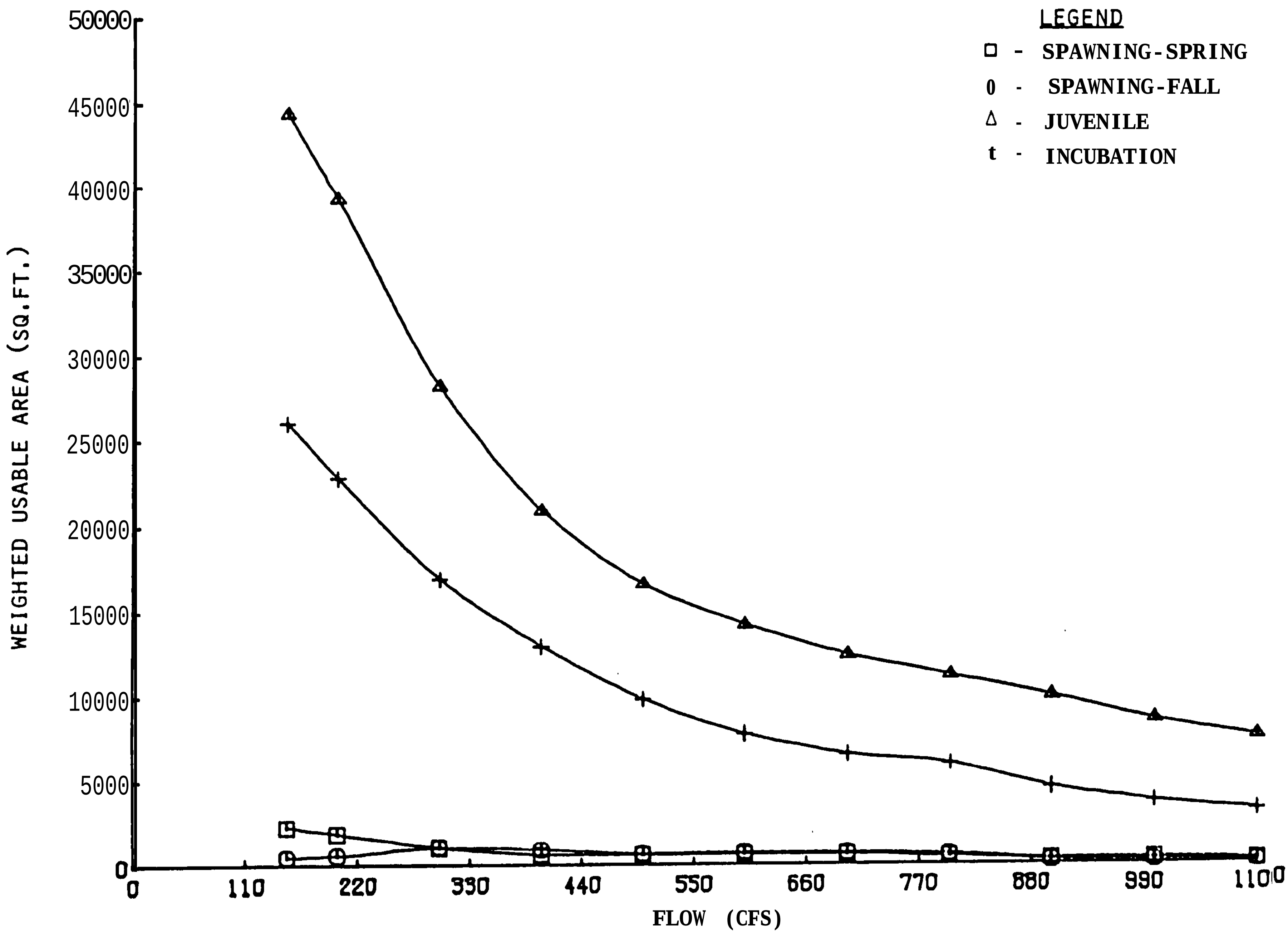


WARM SPRINGS RIVER W-2



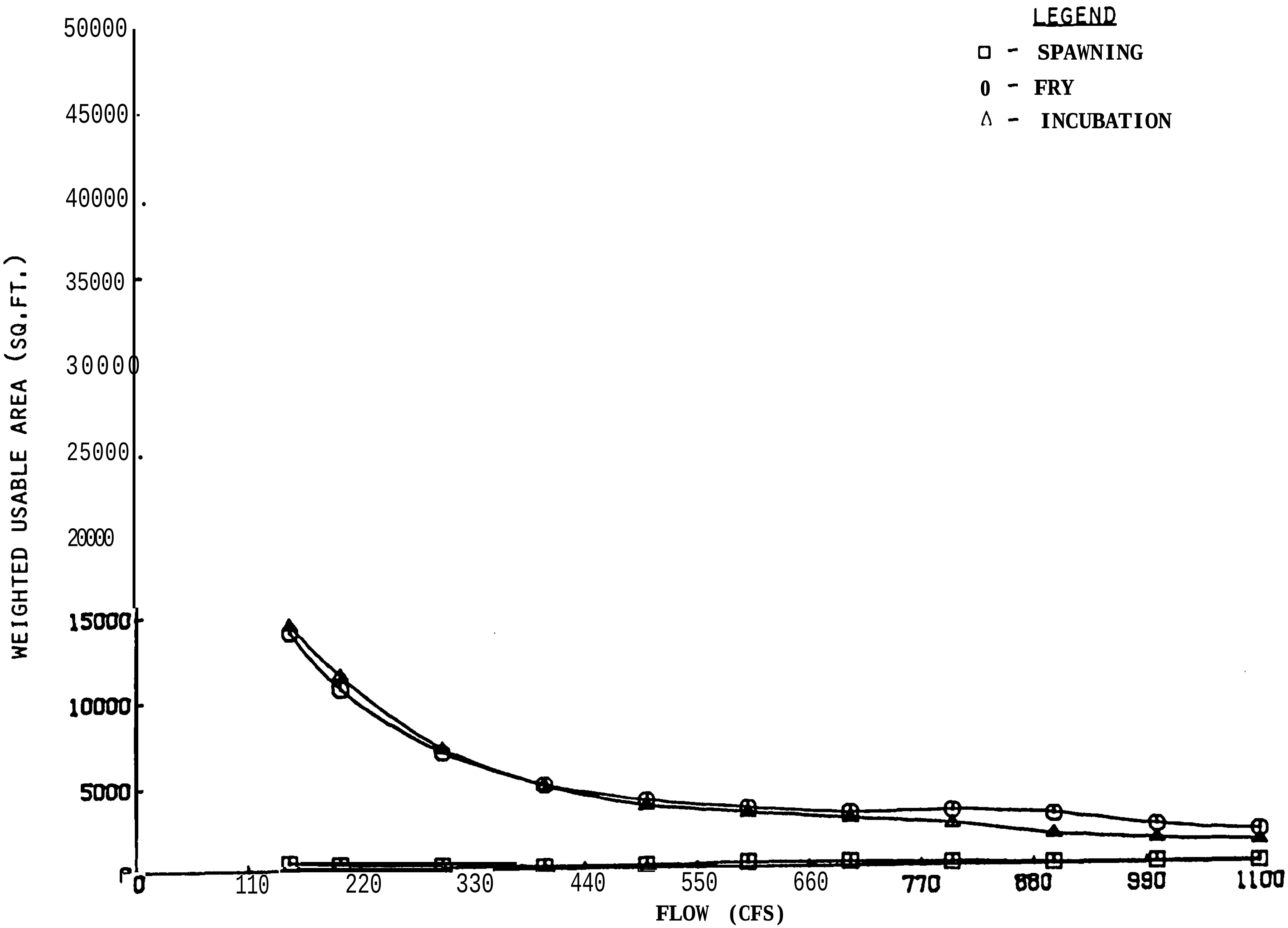
WARM SPRINGS RIVER 1-2

STEELHEAD (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-2

CHINOOK SALMON (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-2

COHO SALMON (CLEARWATER, S = ,004)

WARM SPRINGS RIVER (W-Z)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.)
PER 1,000 FEET OF STREAM

STEELHEAD

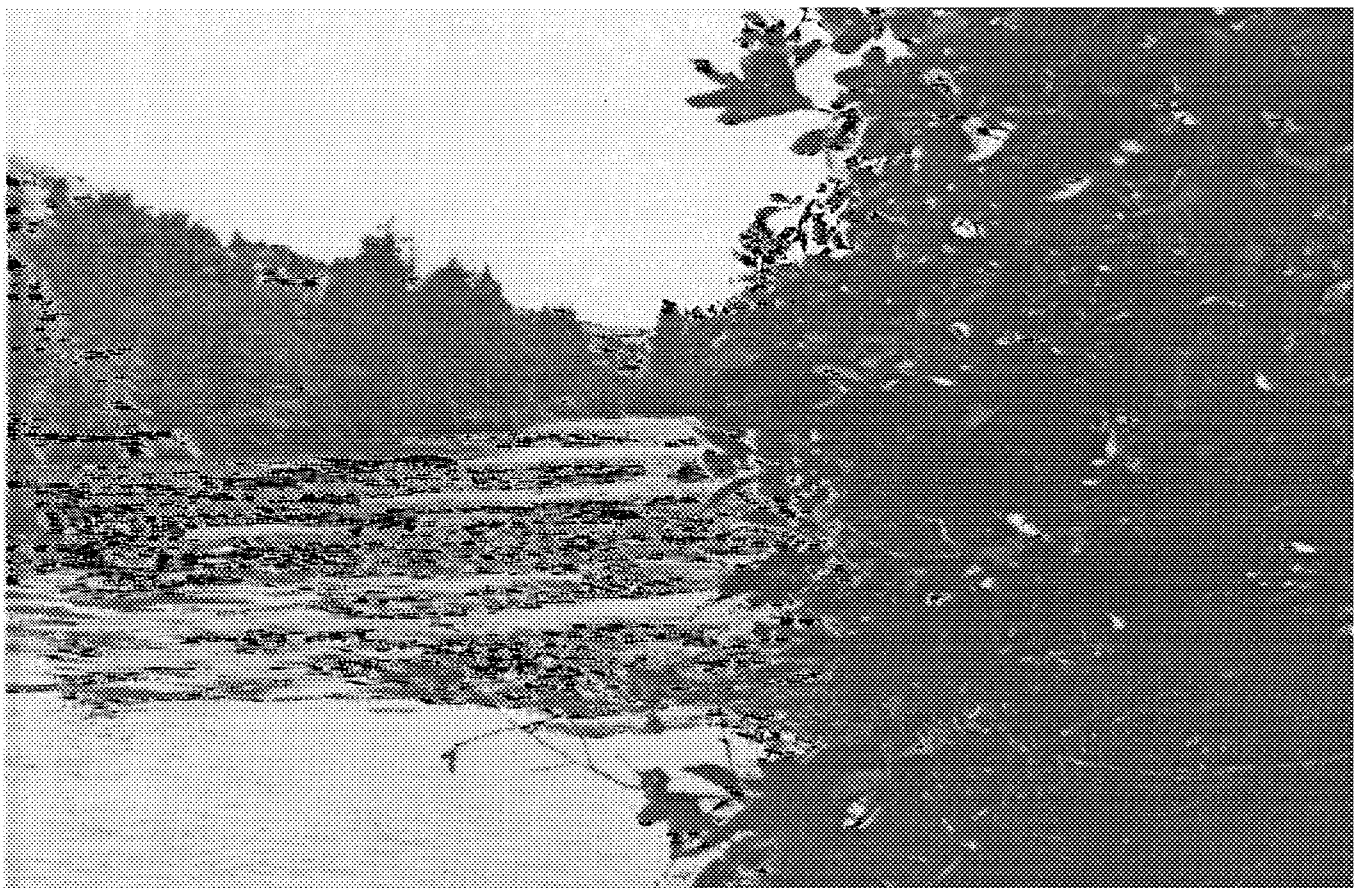
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
150	1603	3751	48328	43469	38257
200	2733	6668	48453	38683	35597
300	3240	12581	43407	30272	29511
400	2441	17779	36711	24061	24728
500	1437	13567	31089	19125	20559
600	849	8499	25796	14816	16266
700	955	5746	20565	11669	13169
800	1345	4991	16641	9395	11535
900	753	4748	14111	8047	9639
1000	432	4619	12473	7096	8164
1100	267	3925	11277	6569	6859

CHINOOK **SALMON**

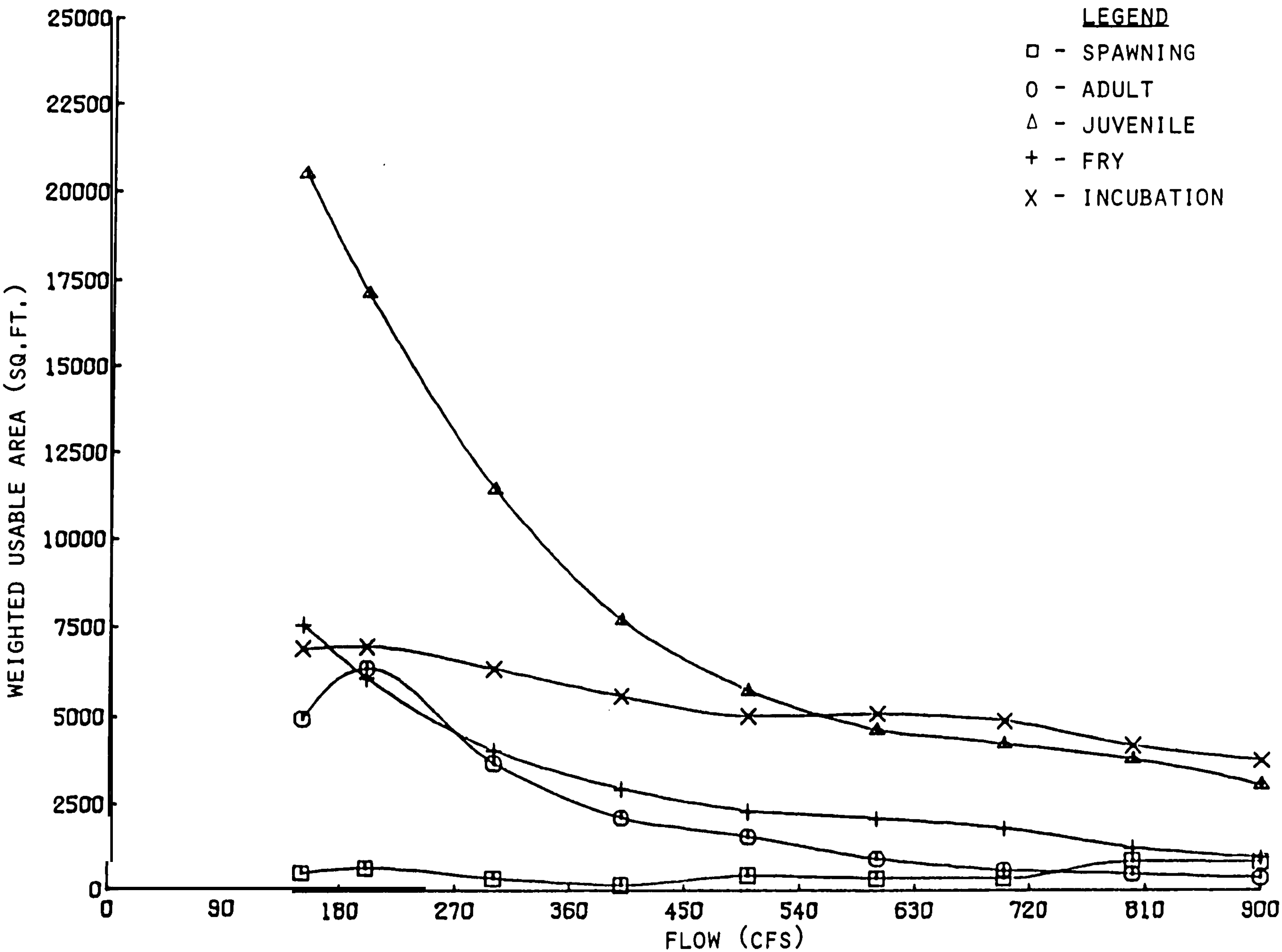
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
150	2259	526	44381	26076
200	1857	608	39273	22889
300	1068	1088	28243	16930
4oc	643	934	20918	12941
500	633	673	16552	9810
600	644	748	14186	7774
700	634	697	12388	6574
800	478	644	11157	6019
900	349	262	9958	4605
1000	398	219	8554	3747
1100	267	199	7590	3215

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
150	527	14100	14500
200	381	10741	11518
300	300	7010	7226
400	202	5053	4991
500	215	4084	3756
600	331	3544	3272
700	300	3235	2857
800	237	3298	2510
900	122	3026	1813
1000	121	2297	1484
1100	100	1940	1331

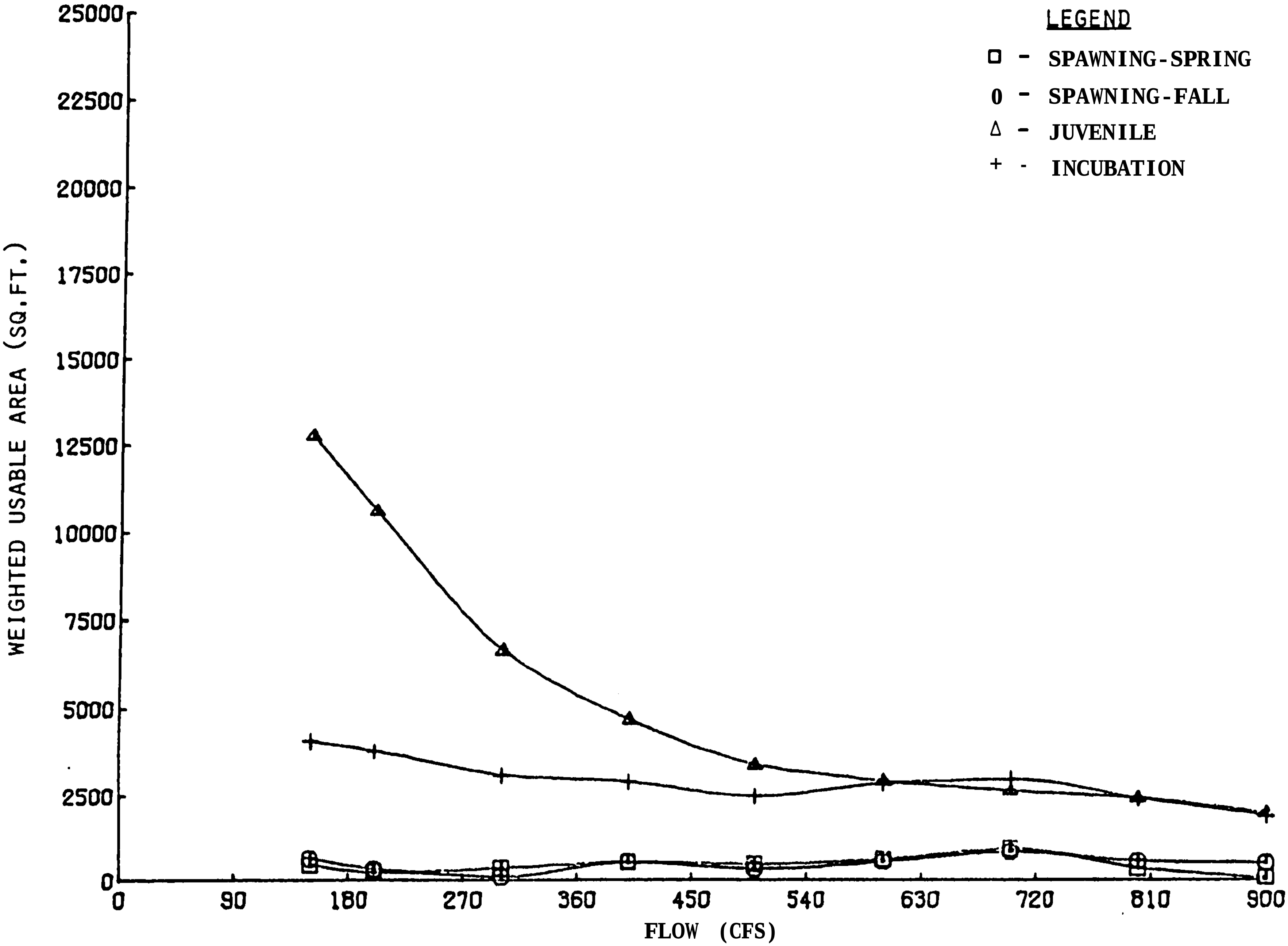


WARM SPTINGS RIVER W - 3



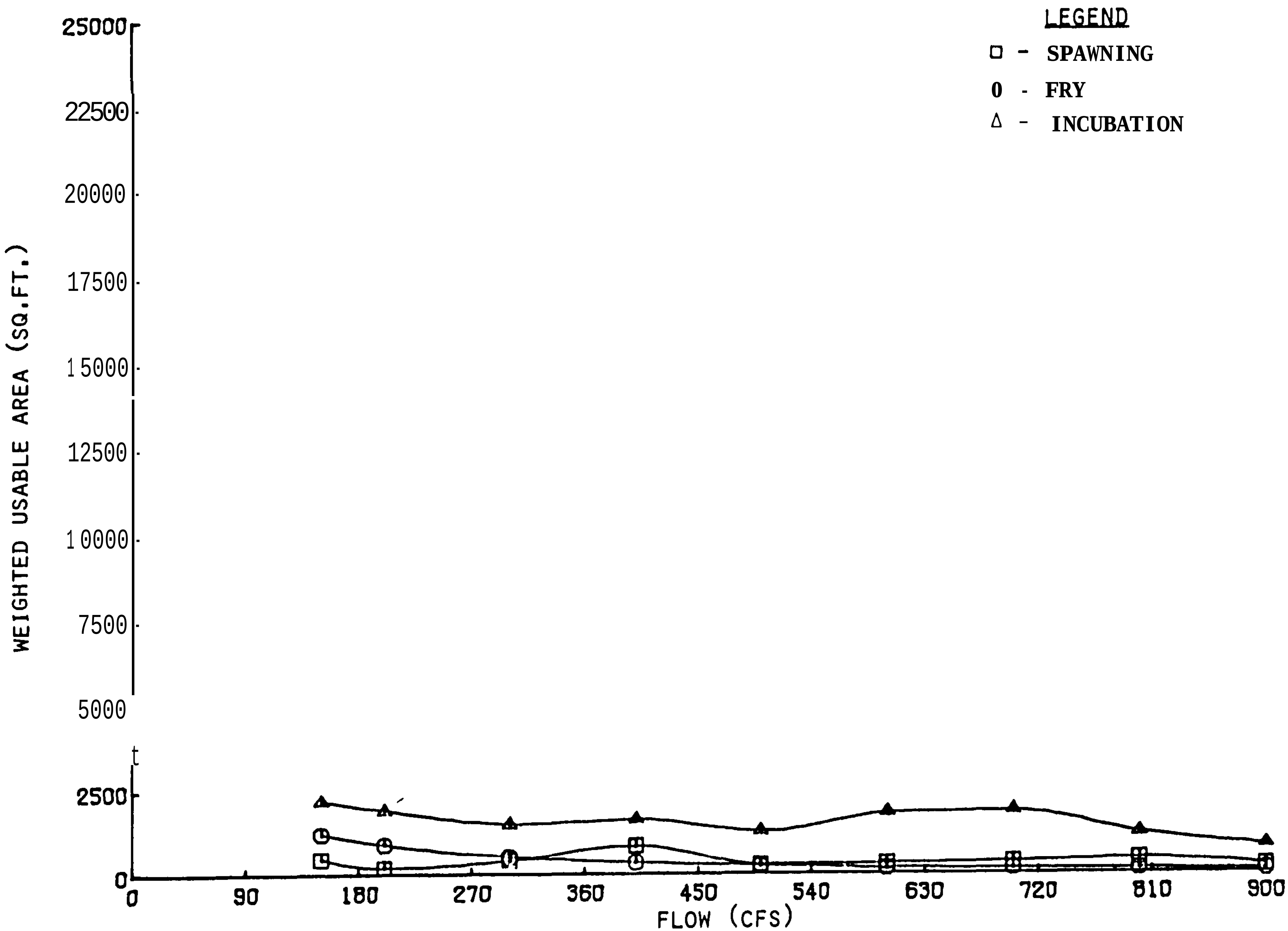
WARM SPRINGS RIVER W-3

STEELHEAD (CLEARWATER, S = .004)



WARM SPRINGS RIVER W-3

CHINOOK SALMON (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-3

COHO SALMON (CLEARWATER, S = ,004)

WARM SPRINGS RIVER (W-3)

DISHCARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.)
PER 1,000 FEET OF STREAM

STEELHEAD

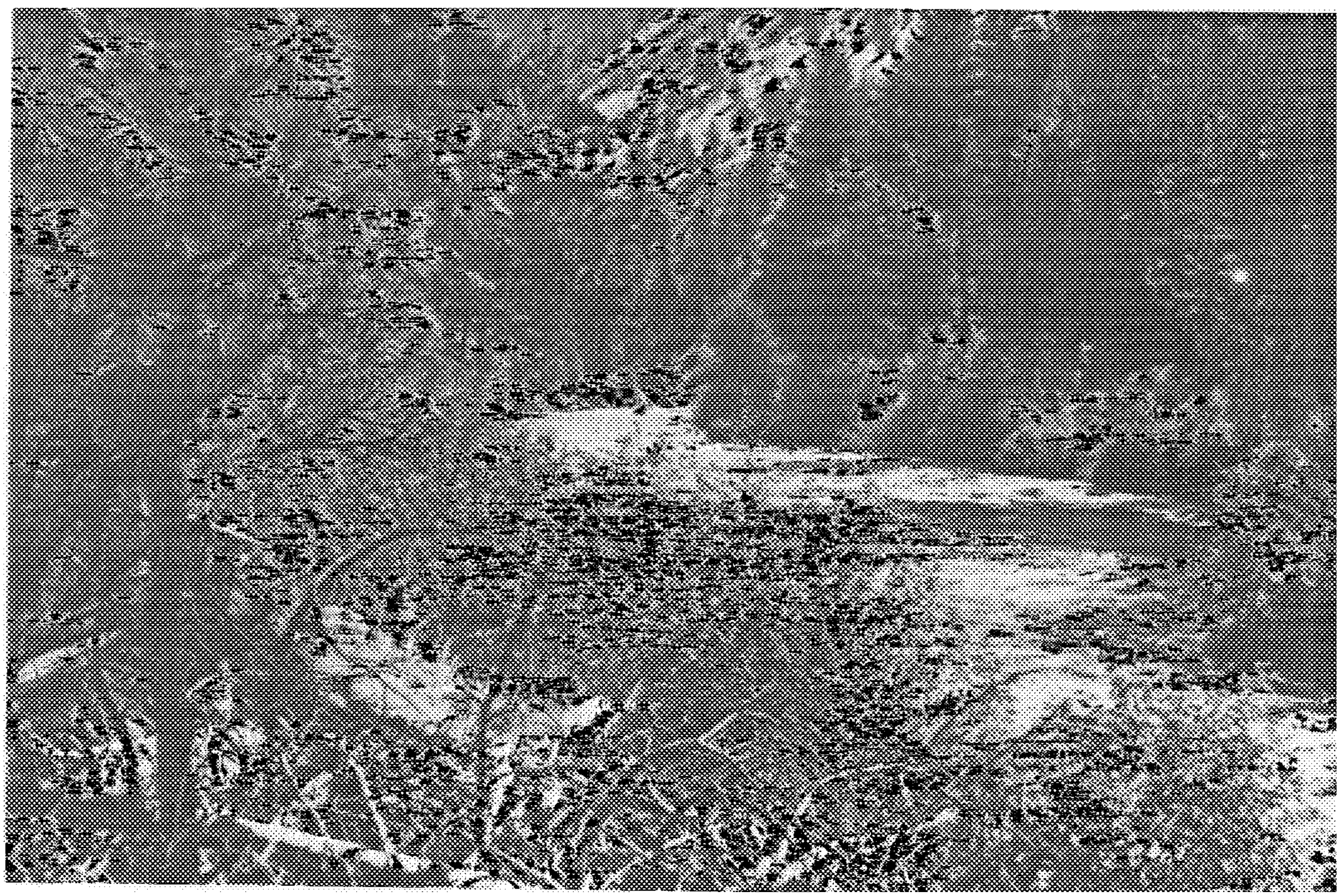
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
150	557	5021	20612	7642	6985
200	694	6431	17216	6152	7024
300	379	3732	11519	4094	6391
400	189	2164	7742	3003	5633
500	469	1604	5775	2356	5064
600	386	955	4665	2140	5131
700	382	623	4261	1852	4924
800	894	503	3816	1278	4220
900	869	387	3079	987	3790

CHINOOK SALMON

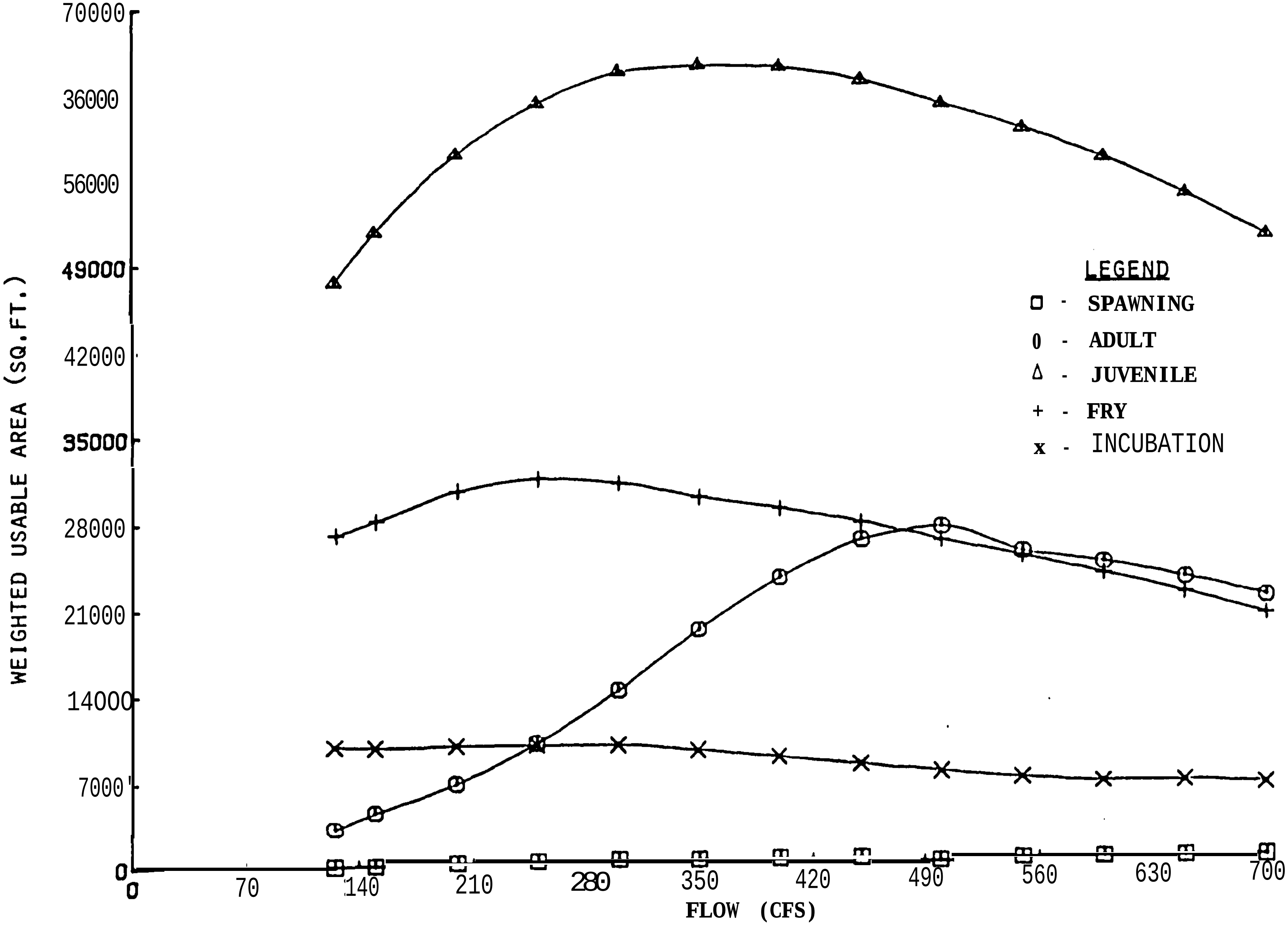
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
150	468	648	12789	4090
200	249	351	10635	3807
300	380	128	6672	3099
400	543	544	4696	2907
500	485	341	3386	2491
600	633	558	2916	2868
700	928	839	2635	2977
800	362	567	2423	2431
900	98	518	1982	1902

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
150	488	1241	2216
200	216	923	1938
300	436	536	1527
400	887	366	1655
500	294	257	1300
600	333	182	1852
700	385	162	1888
800	462	140	1241
900	242	131	856

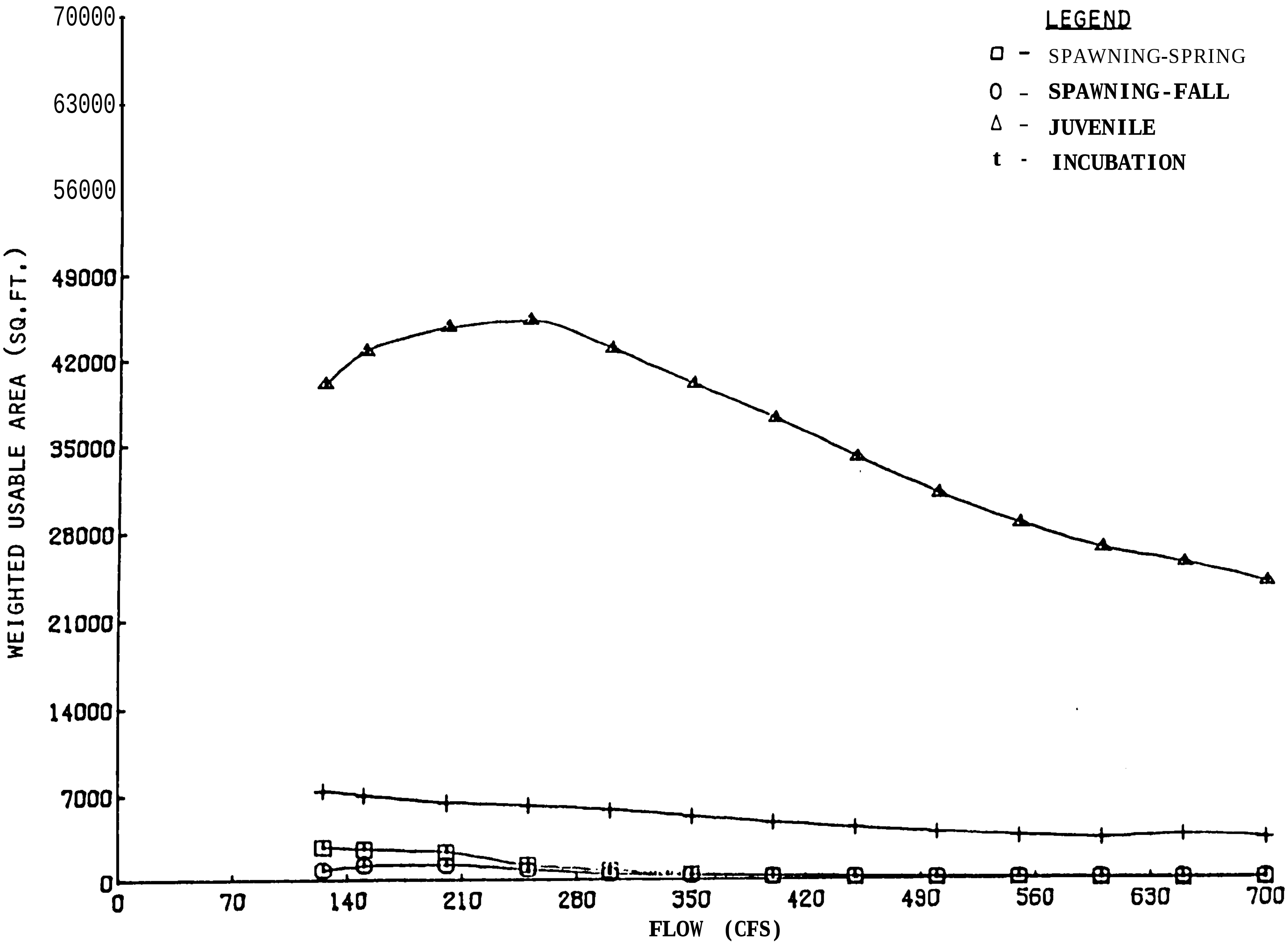


WARM SPRINGS RIVER W-4



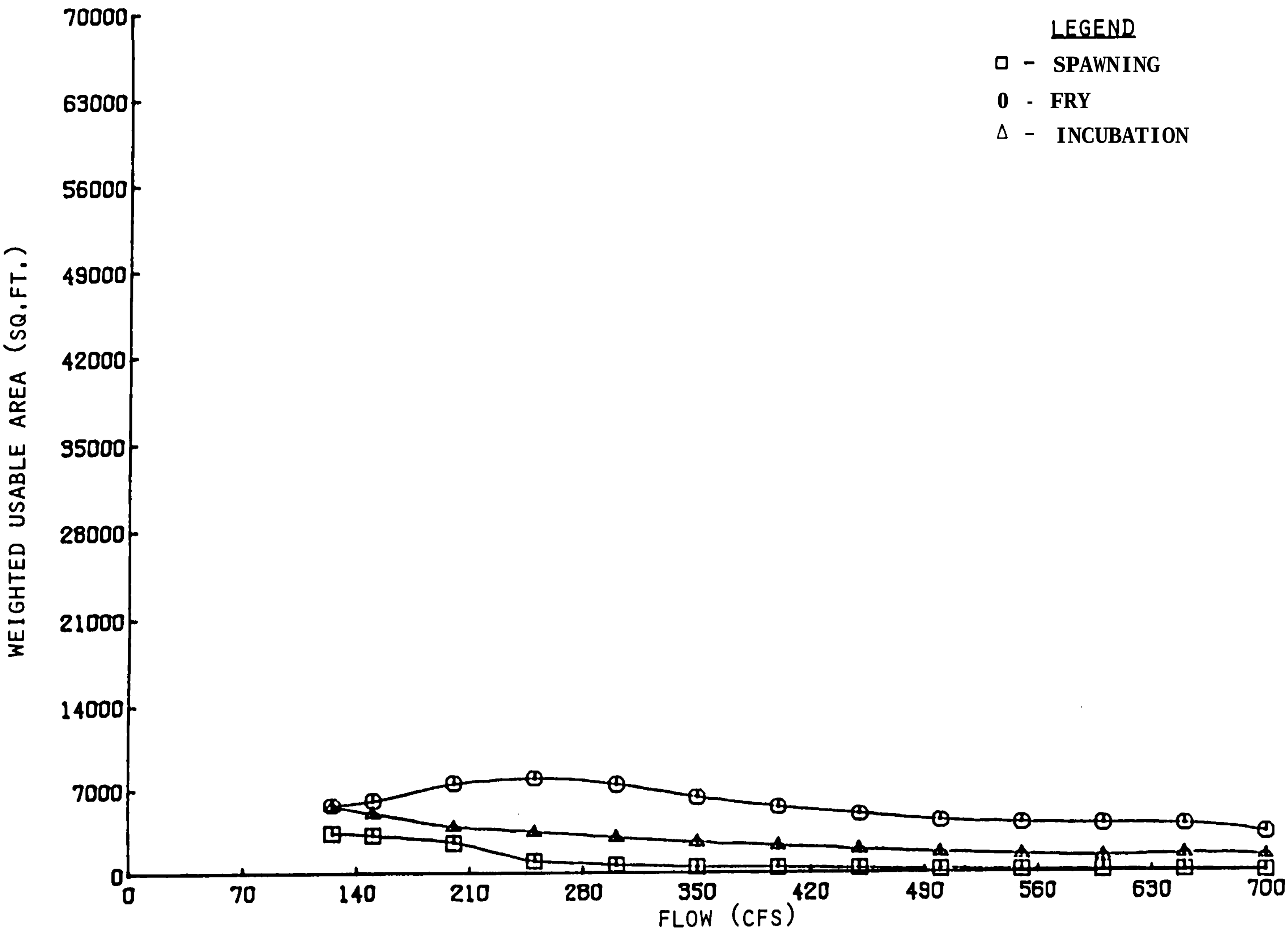
W A R M S P R I N G S R I V E R W - 4

STEELHEAD (CLEARWATER, S = .004)



WARM SPRINGS RIVER W-4

CHINOOK SALMON (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-4

COHO SALMON (CLEARWATER, S = ,004)

WARM SPRINGS RIVER (W-4)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 1,000 FEET OF STREAM

STEELHEAD

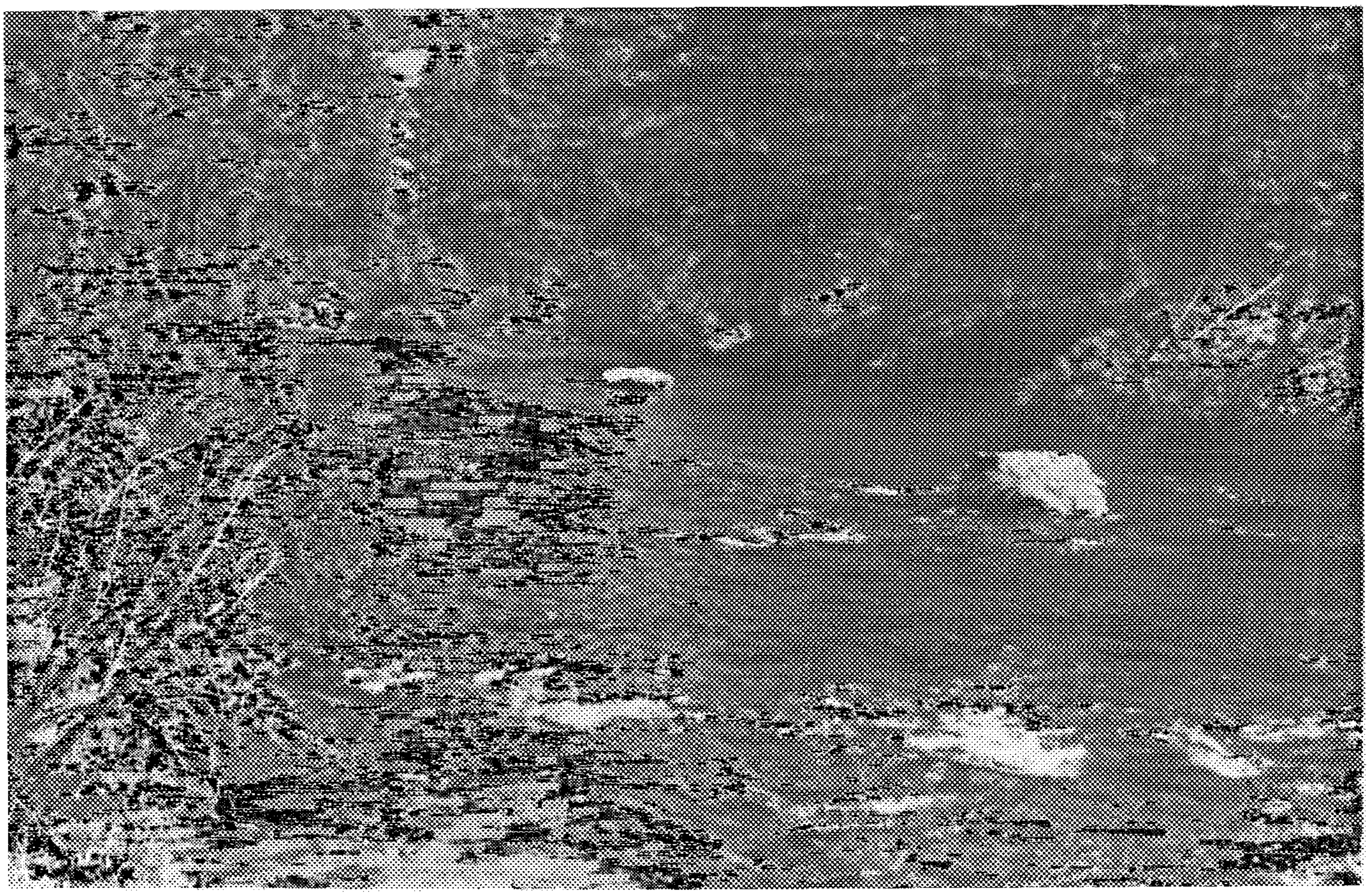
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
150	79	4465	51683	28240	9770
200	184	6902	58097	30672	9907
250	271	10098	62335	31615	9991
300	290	14351	64831	31246	9934
350	261	19277	65290	30046	9436
400	224	23455	65099	29053	8798
450	184	26510	63974	27868	8159
500	146	27488	62045	26424	7561
550	118	25435	59968	25042	7032
600	96	24525	57488	23598	6674
650	78	23232	54435	22015	6682
700	62	21668	51019	20235	6438

CHINOOK SALMON

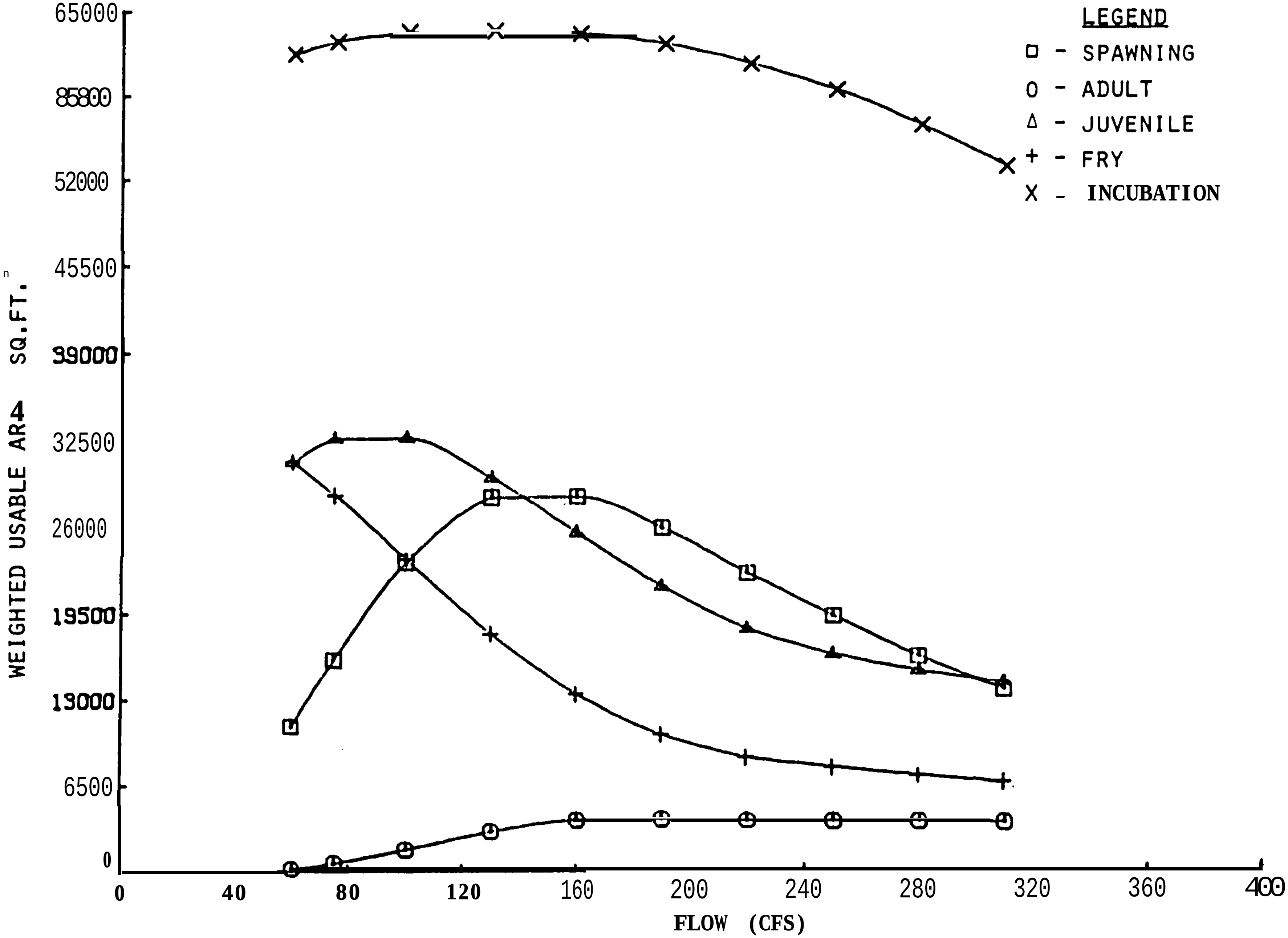
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
150	2590	1261	42846	7040
200	2368	1312	44788	6452
250	1282	906	45312	6218
300	837	548	42970	5867
350	583	402	40106	5317
400	369	329	37313	4781
450	265	286	34092	4314
500	190	255	31154	3927
550	136	233	28684	3594
600	80	218	26717	3407
650	48	206	25505	3673
700	66	198	23939	3370

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
150	3181	6143	5023
200	2594	7519	3909
250	1058	7932	3452
300	699	7382	2982
350	548	6315	2562
400	483	5511	2271
450	399	4905	1963
500	317	4340	1702
550	244	4101	1508
600	202	4007	1365
650	149	3954	1536
700	80	3249	1312

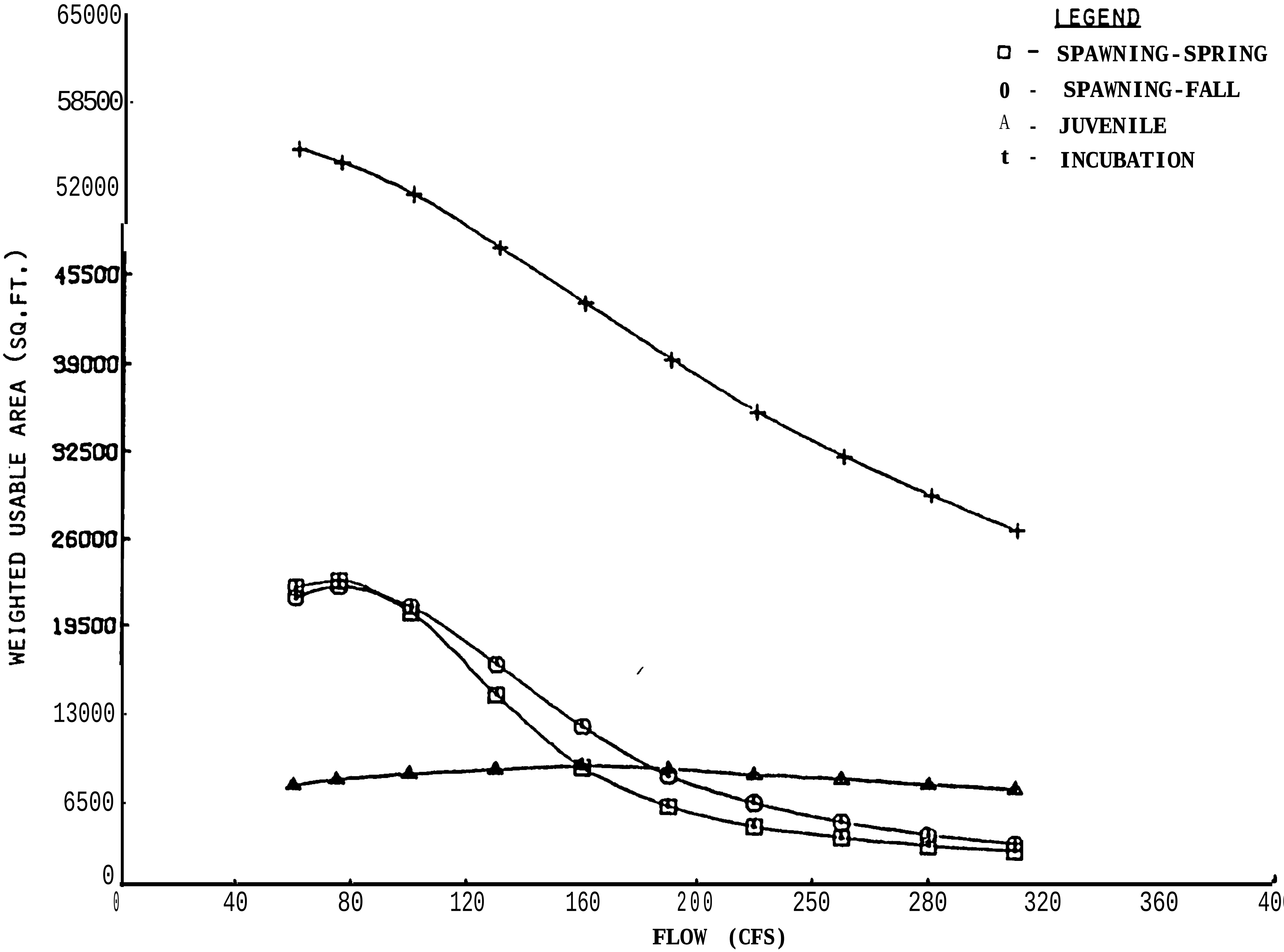


WARM SPRINGS RIVER W-5



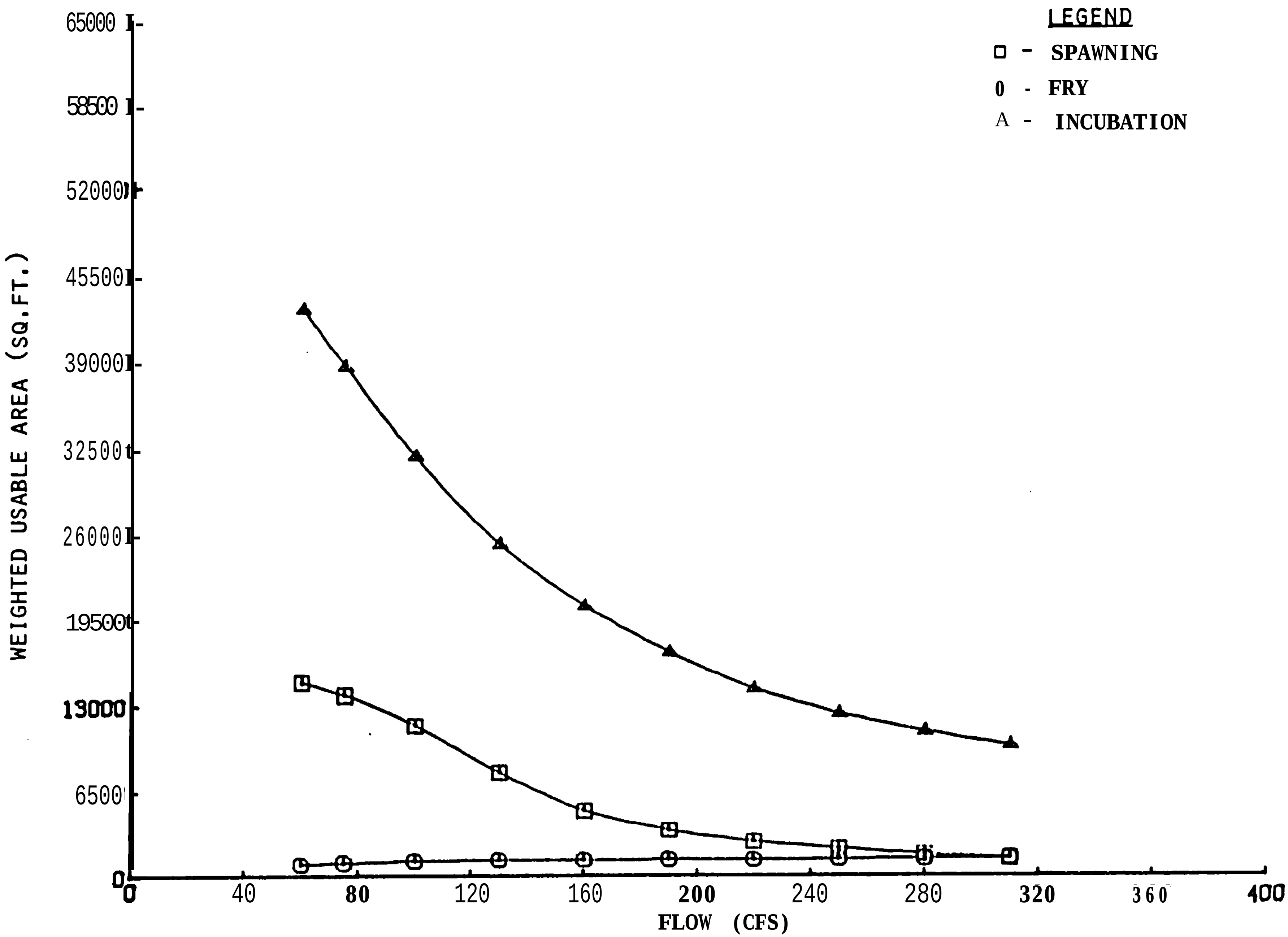
WARM SPRINGS RIVER W-5

STEELHEAD (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-5

CHINOOK SALMON (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-5

COHO SALMON (CLEARWATER, S = ,004)

WARM SPRINGS RIVER (W-5)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.)
PER 1,000 FEET OF STREAM

STEELHEAD

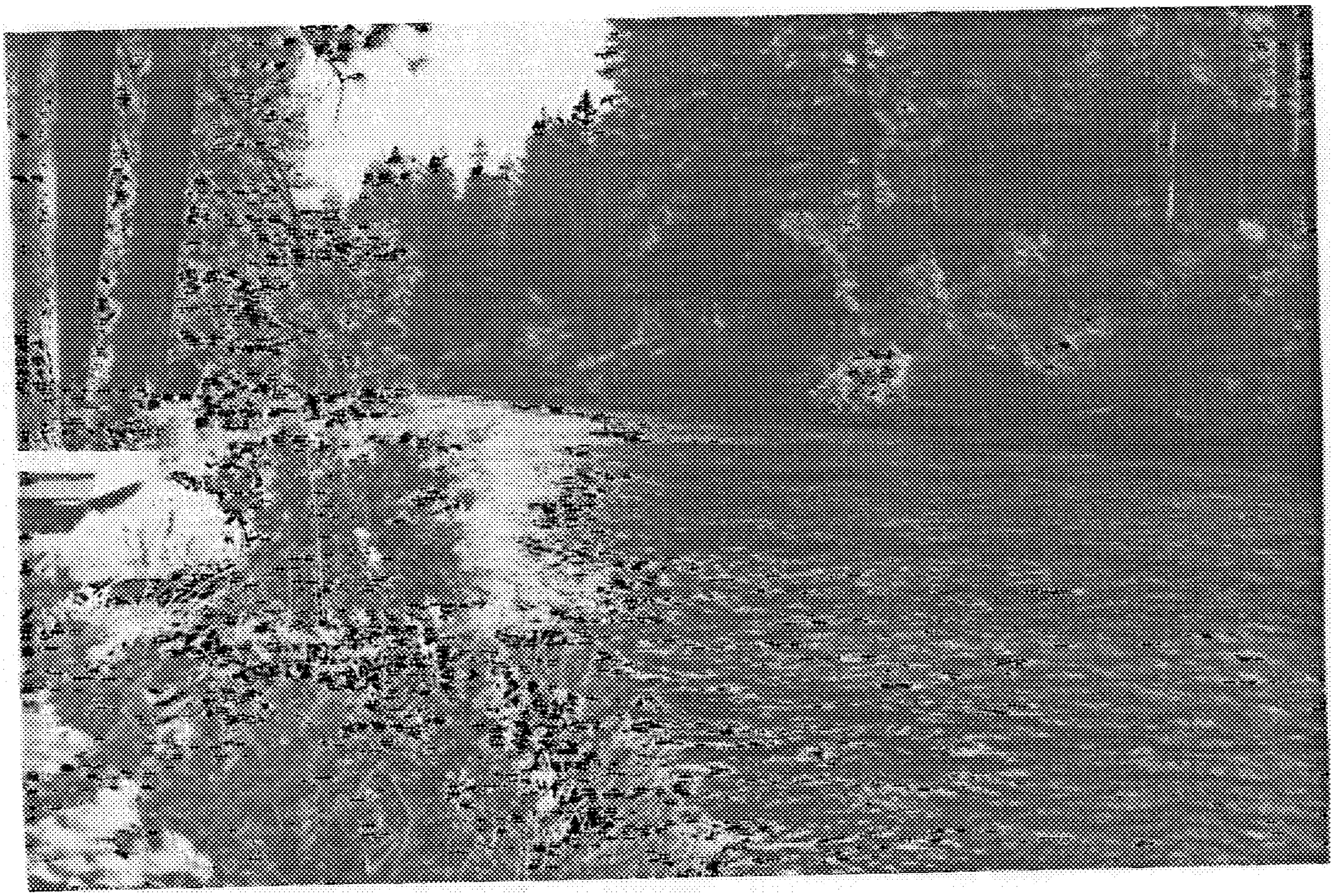
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
100	2164	5803	36323	24814	27859
150	4107	7311	37396	23369	30659
200	5003	7639	35438	20022	31360
250	5337	8339	31909	16746	30882
300	5374	9339	27372	13618	29772
350	4752	6836	22213	11028	28141
400	4134	5461	18528	9305	26364
450	3731	4822	16091	7894	24412
500	3539	4100	14366	6828	22476

CHINOOK SALMON

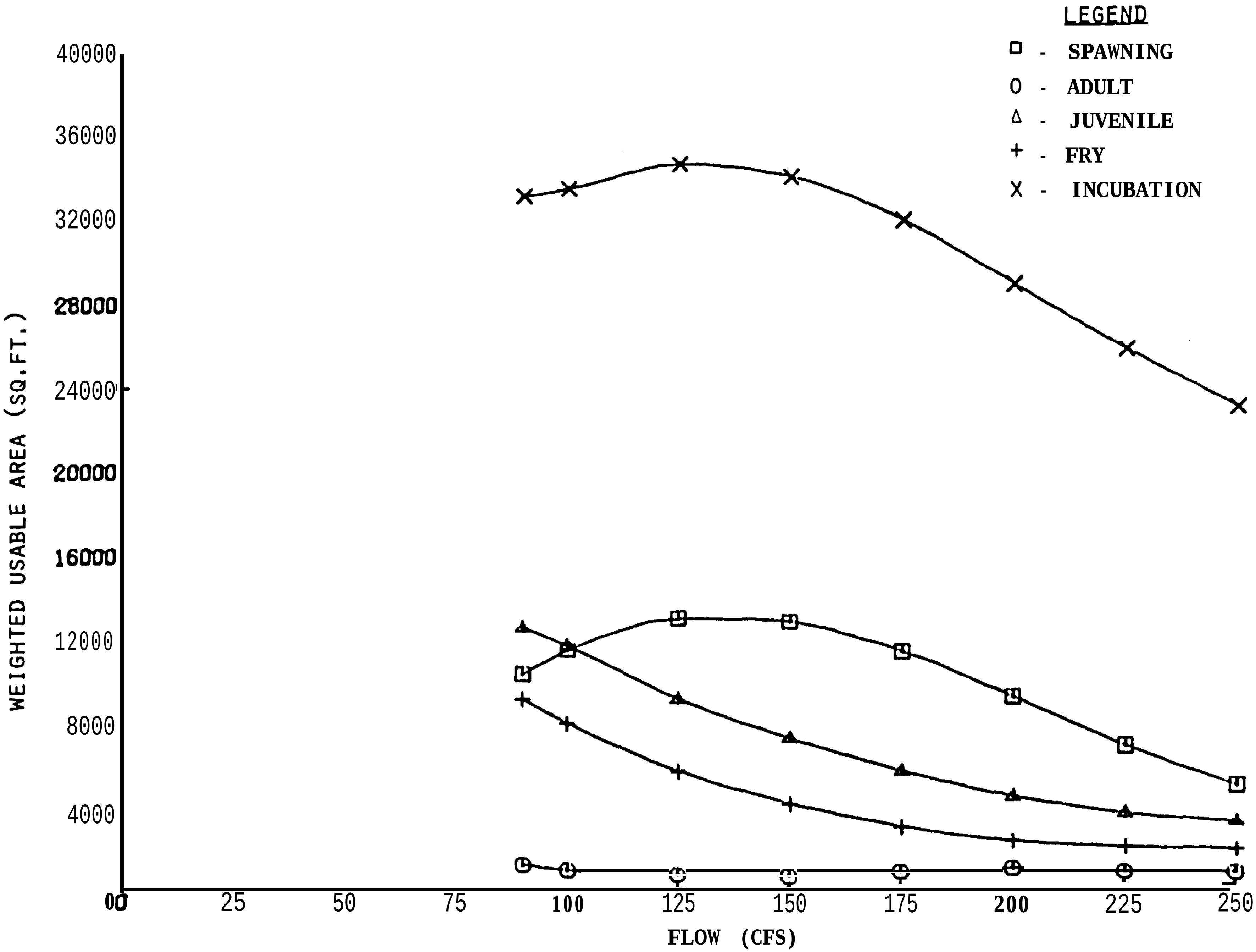
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
100	3452	3023	20101	22620
150	3950	3670	18271	22794
200	3620	3282	15256	22188
250	2975	2678	11879	20797
300	2551	2853	9292	18996
350	2098	2464	7430	17223
400	2015	2068	6089	15648
450	2002	2018	5129	14137
500	1711	1674	4578	12706

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
100	3295	5368	17967
150	2784	4023	15725
200	1952	2616	14259
250	2165	1676	12425
300	1995	1180	10569
350	1836	889	9167
400	1681	729	8202
450	1402	616	7233
500	1009	528	6246

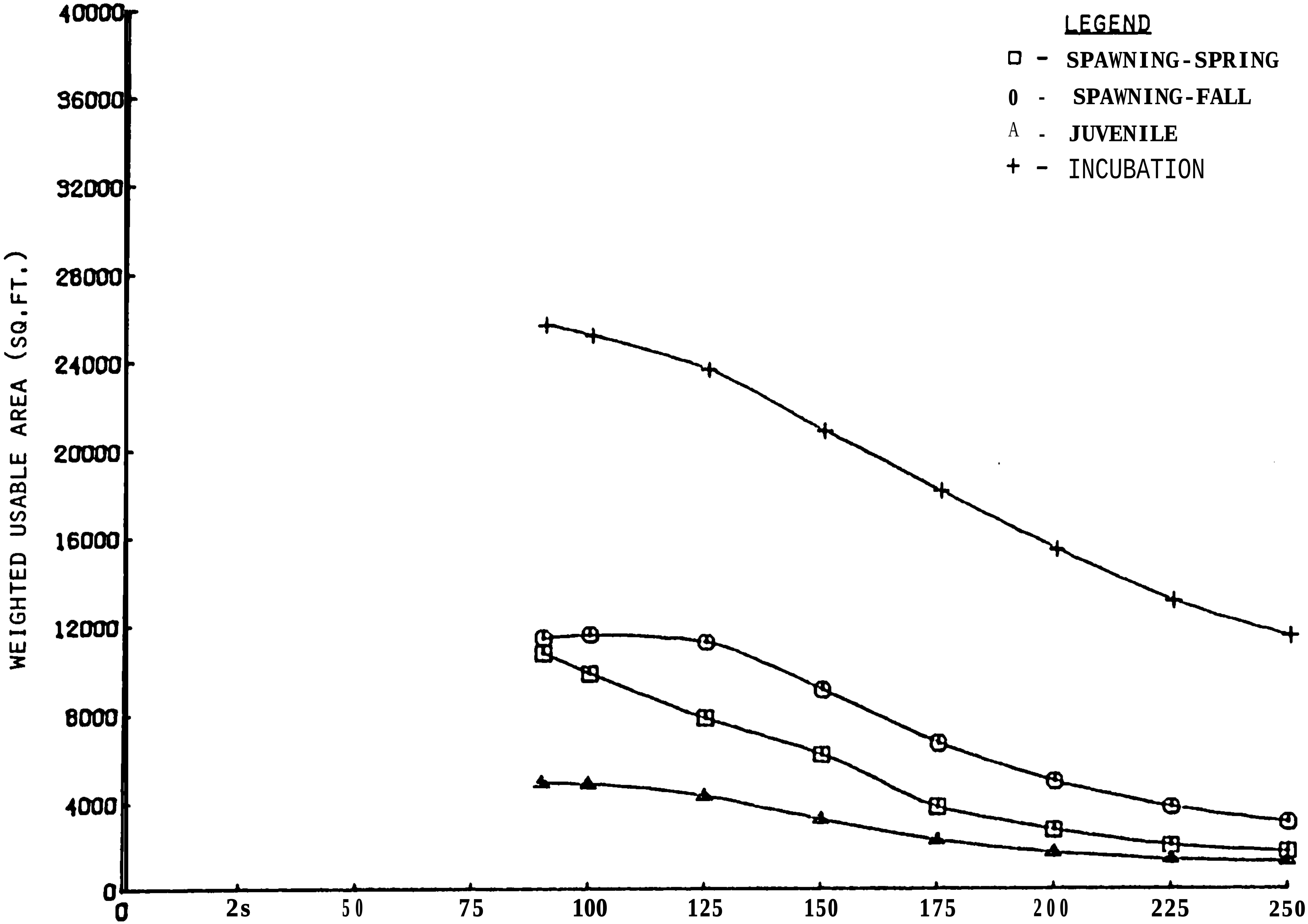


WARM SPRINGS RIVER W-6



WARM SPRINGS RIVER W-6

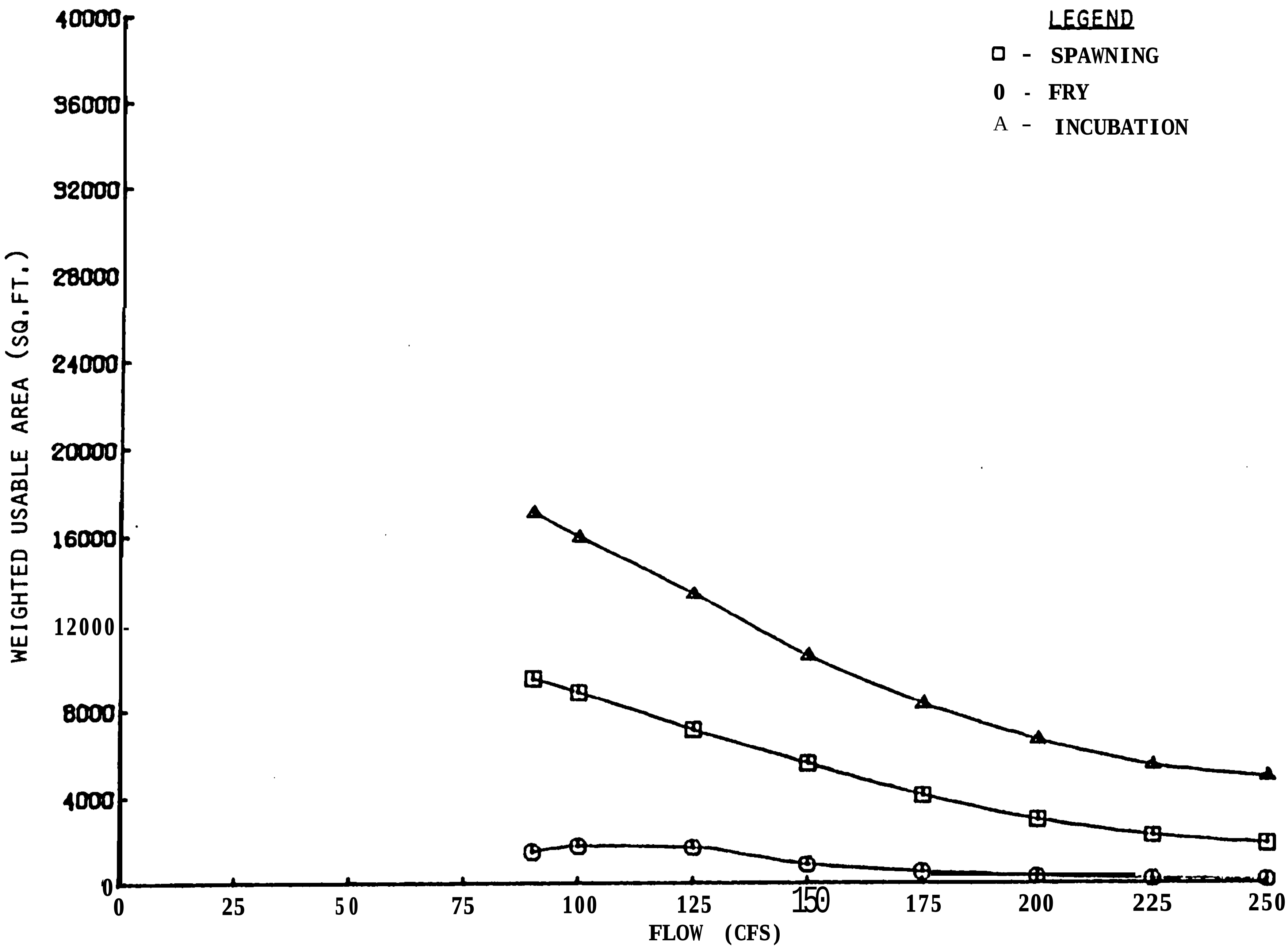
STEELHEAD (CLEARWATER, S = ,004)



FLOW (CFS)

WARM SPRINGS RIVER W-6

CHINOOK SALMON (CLEARWATER, S = .004)



WARM SPRINGS RIVER W-6

COHO SALMON (CLEARWATER, S = ,004)

WARM SPRINGS RIVER (W-6)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.)
PER 1,000 FEET OF STREAM

STEELHEAD

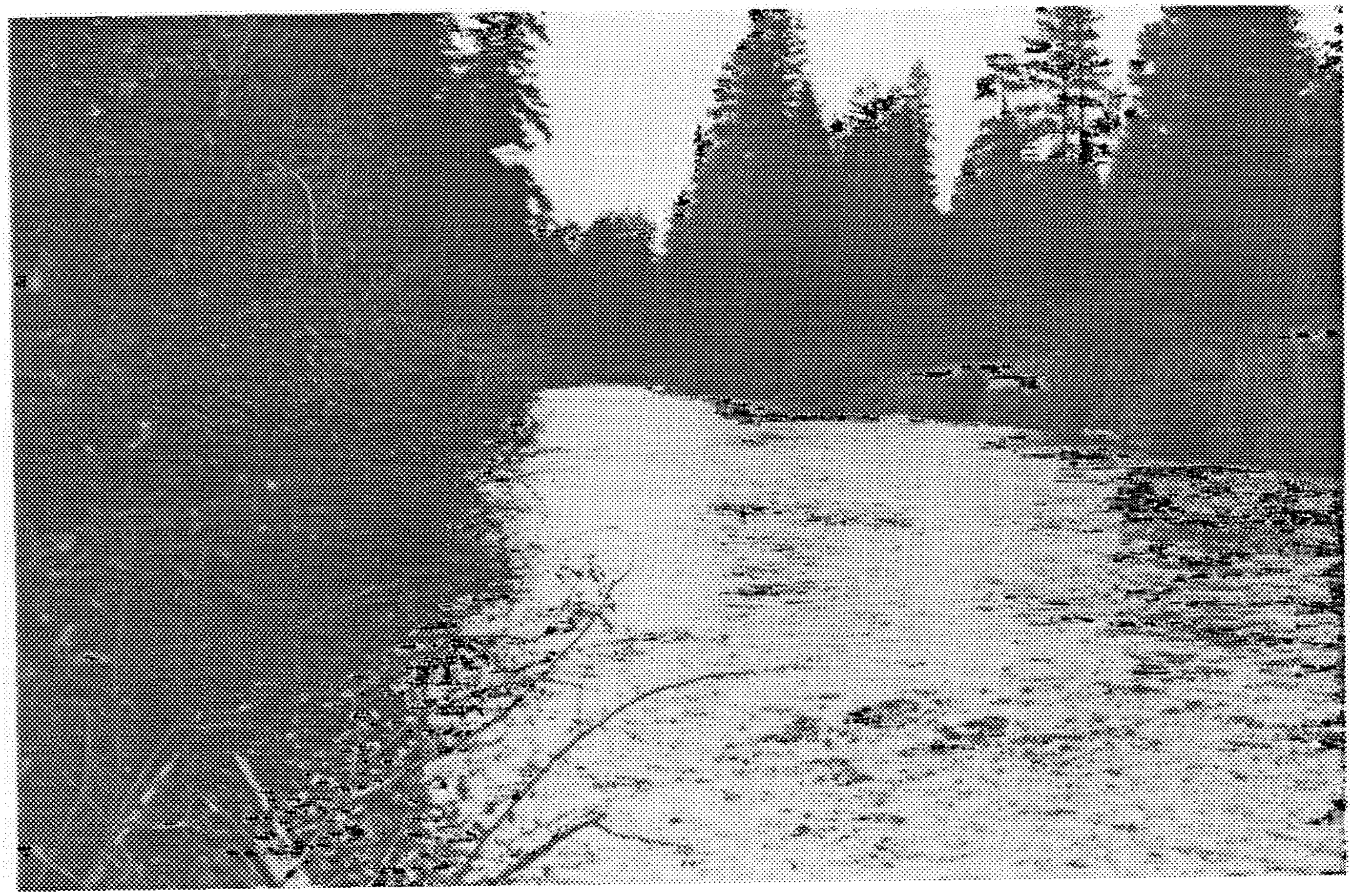
DISCHARGE	**SPAWNING**	ADULT	JUVENILE	FRY	INCUBATION
90	10206	1269	12394	9013	**32847**
100	11307	977	11502	7887	33195
125	12758	720	8932	5644	34336
150	12558	622	7078	4100	33653
175	11069	783	5527	2937	31560
200	8871	842	4306	2169	28592
225	6591	694	3475	1828	25506
250	4737	610	3026	1695	22675

CHINOOK **SALMON**

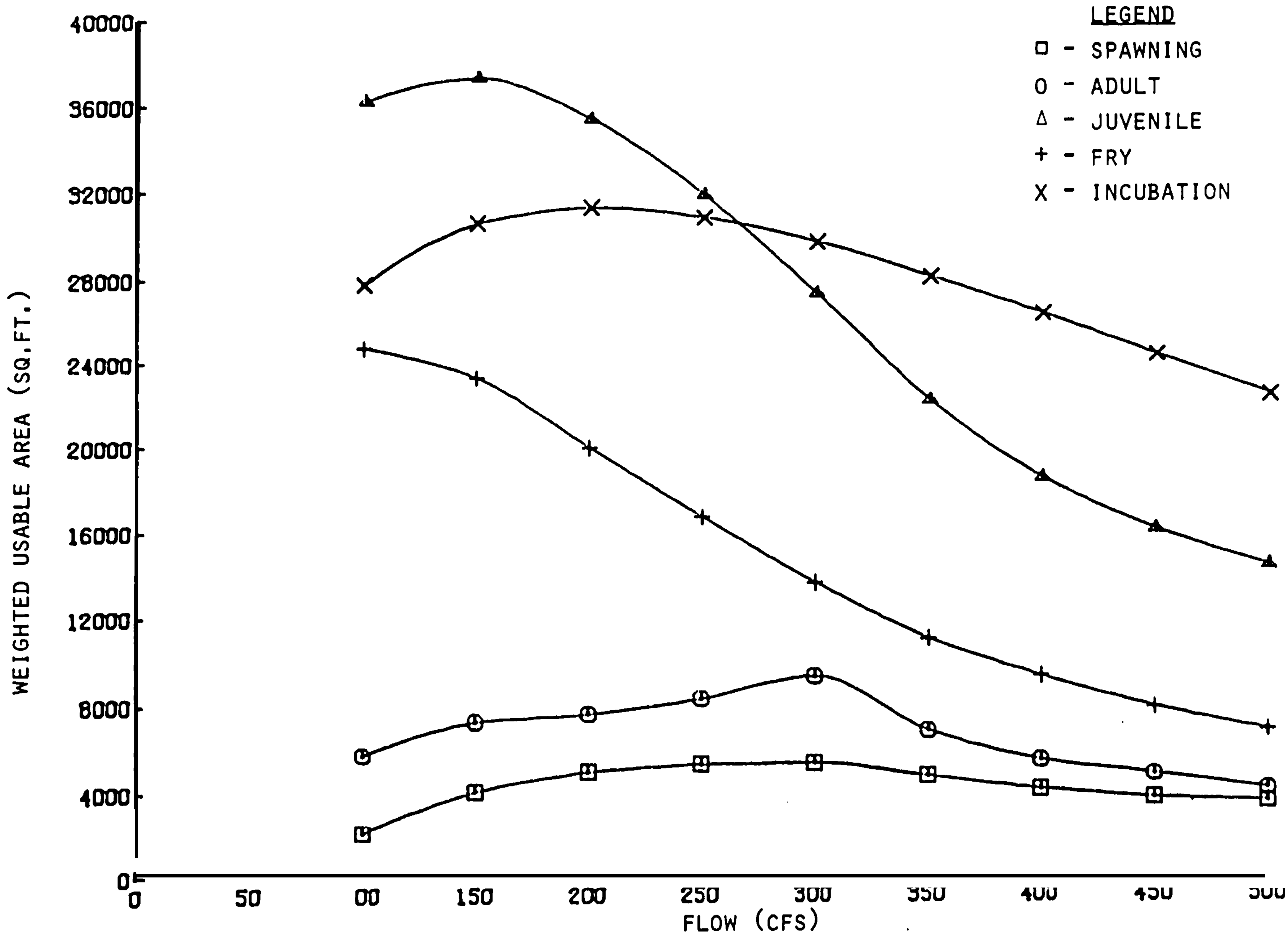
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
90	10771	11459	4934	25725
100	9855	11596	4880	25239
125	7859	11264	4339	23705
150	6244	9154	3266	20922
175	3852	6764	2304	18155
200	2790	5007	1714	15472
225	2048	3834	1375	13127
250	1780	3127	1281	11520

COHO SALMON

DISCHARGE	SPAWNING	**FRY**	INCUBATION
90	**9459**	1497	17141
100	**8833**	1739	15989
125	7124	1686	13318
150	5569	892	10493
175	4100	565	8322
200	2968	361	6660
225	2232	242	5481
250	1850	212	4960

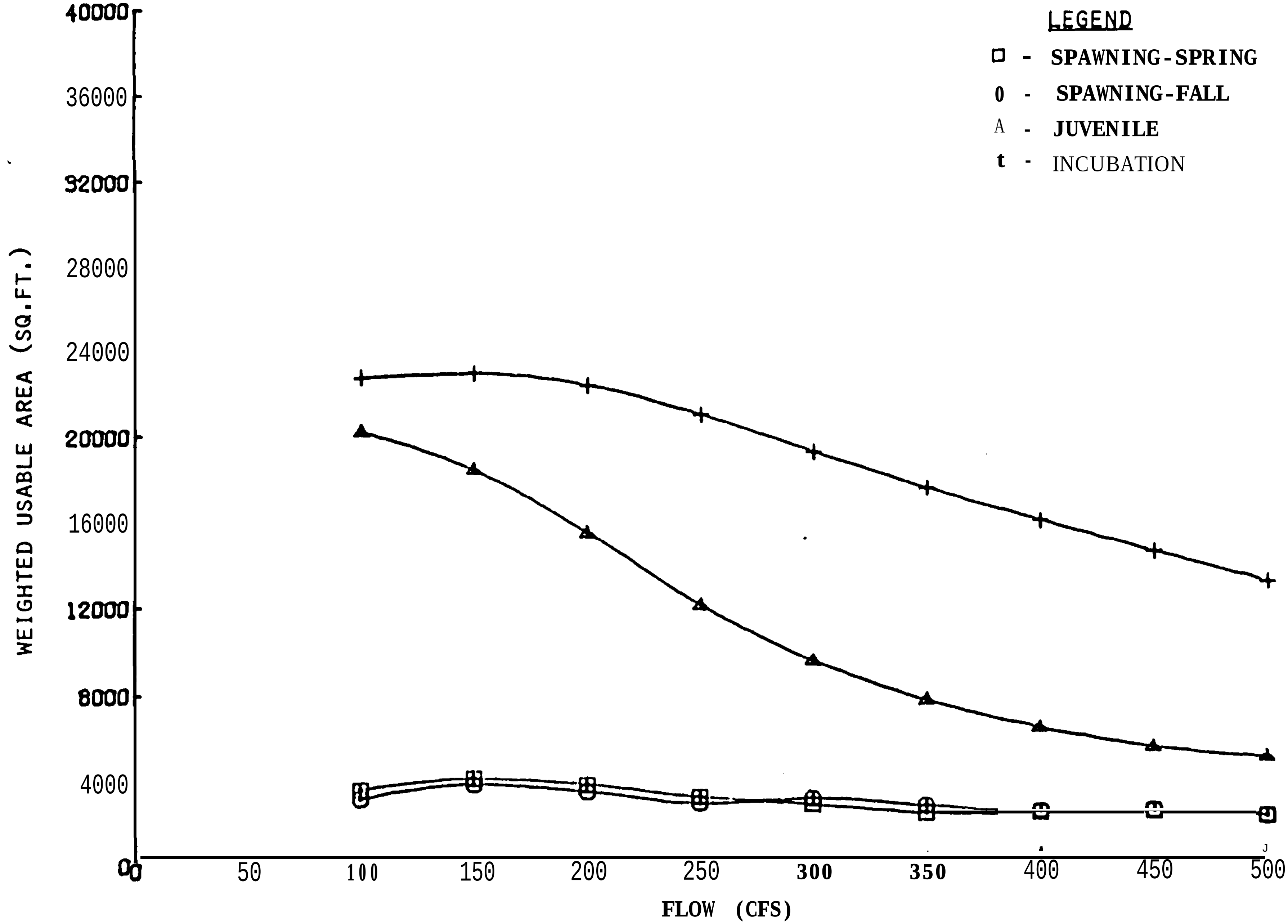


WARM SPRINGS RIVER W-7



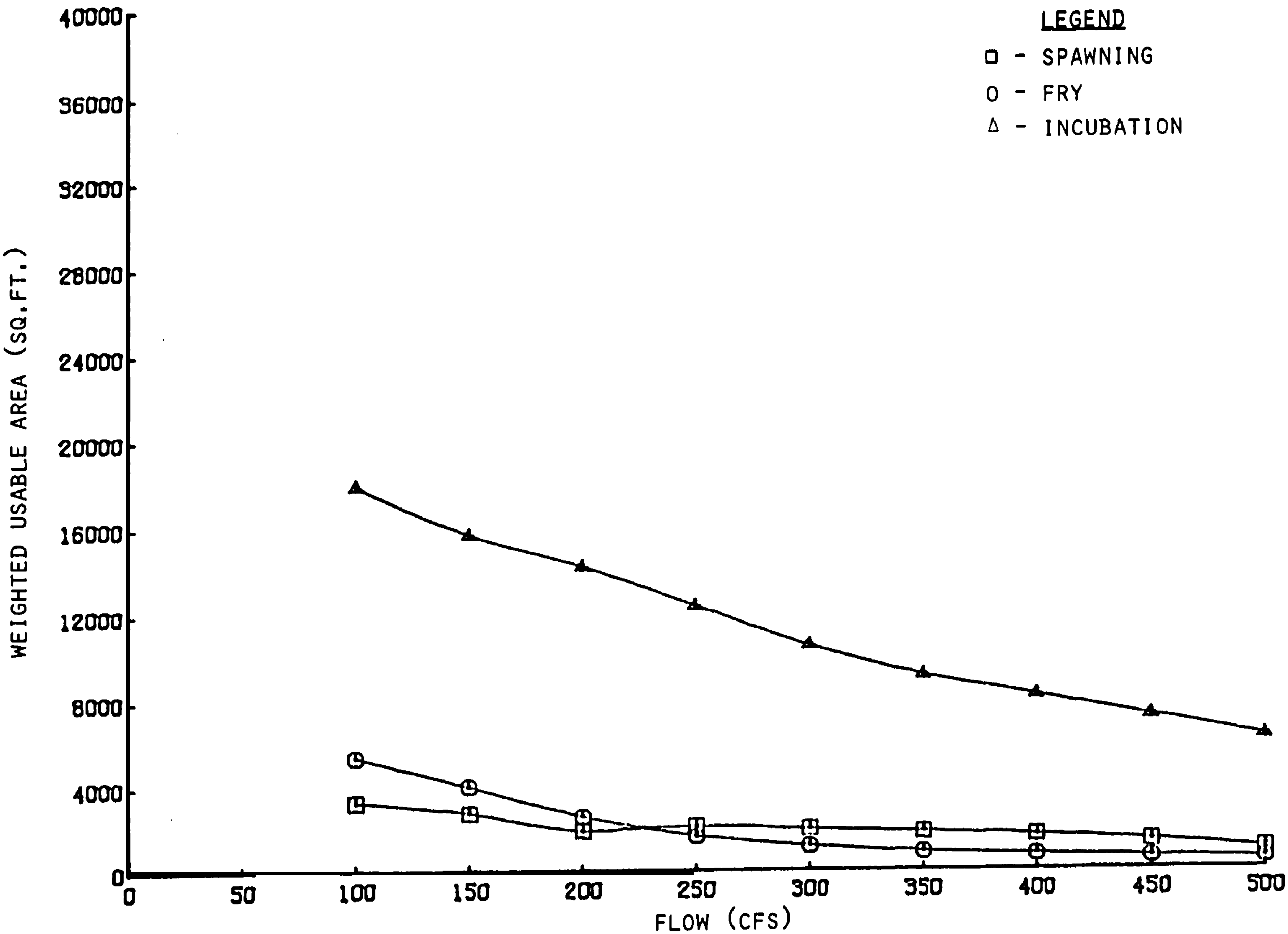
WARM SPRINGS RIVER W-7

STEELHEAD (CLEARWATER, S = .004)



WARM SPRINGS RIVER W-7

CHINOOK SALMON (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-7

COHO SALMON (CLEARWATER, S = .004)

WARM SPRINGS RIVER (W-7)

DISCHARGE **(CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.)**
PER 1,000 **FEET OF STREAM**

STEELHEAD

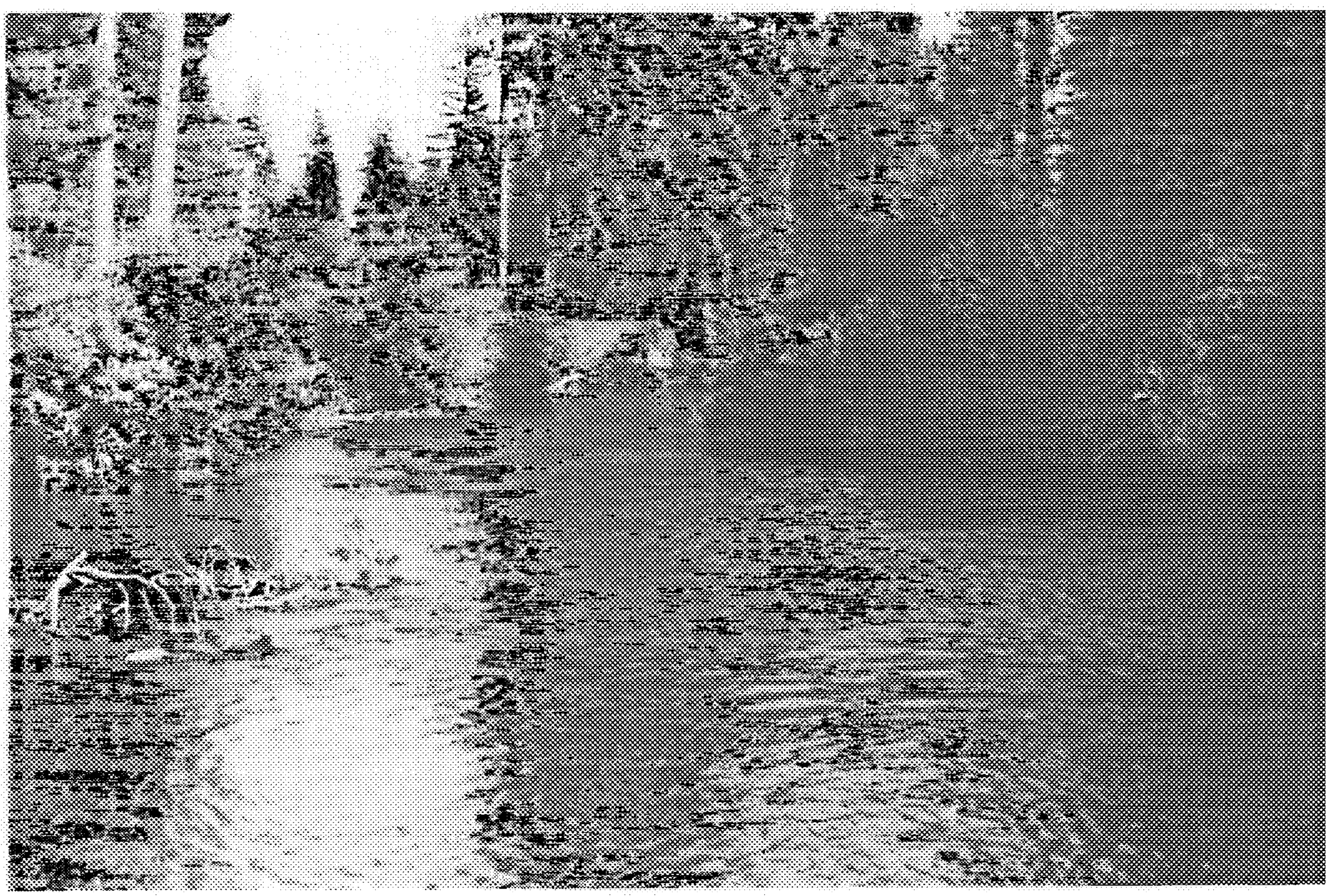
DISCHARGE	SPAWNING	**ADULT**	JUVENILE	FRY	INCUBATION
60	10897	264	30832	30939	61682
75	15953	643	32623	28377	62632
100	23310	1636	32687	23534	63327
130	28200	2983	29685	17916	63417
160	28274	3819	25490	13341	63160
190	25893	3806	21462	10259	62375
220	22504	3657	18300	8531	60892
250	19258	3574	16366	7784	58872
280	16235	3603	15088	7194	56159
310	13664	3448	14214	6680	52987

CHINOOK SALMON

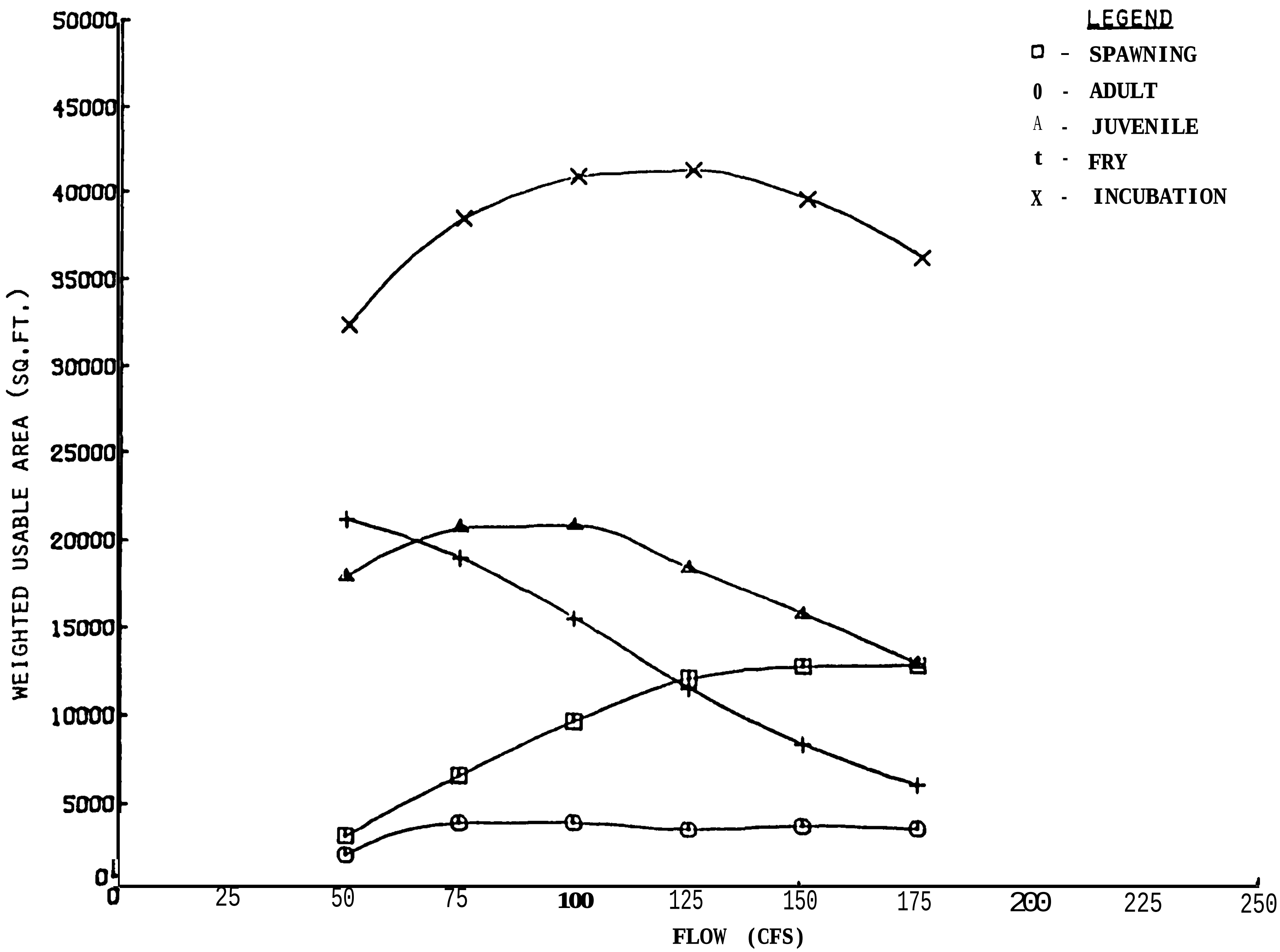
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
60	22297	21504	7558	54804
75	22738	22326	7954	53751
100	20355	20801	8350	51314
130	14091	16372	8607	47367
160	8737	11687	8860	43278
190	5894	8102	8598	39 186
220	4345	6099	8132	35243
250	3471	4650	7770	31881
280	2848	3667	7343	29013
310	2428	2949	6999	26314

COHO SALMON

DISCHARGE	SPAWNING	**FRY**	INCUBATION
60	**14738**	**937**	42860
75	**13793**	1077	38537
100	11532	1211	3 1848
130	7972	1299	25173
160	5053	1287	20450
190	3550	1314	16909
220	2670	1280	14208
250	2145	1341	12352
280	1686	1374	10982
310	1362	1410	9921

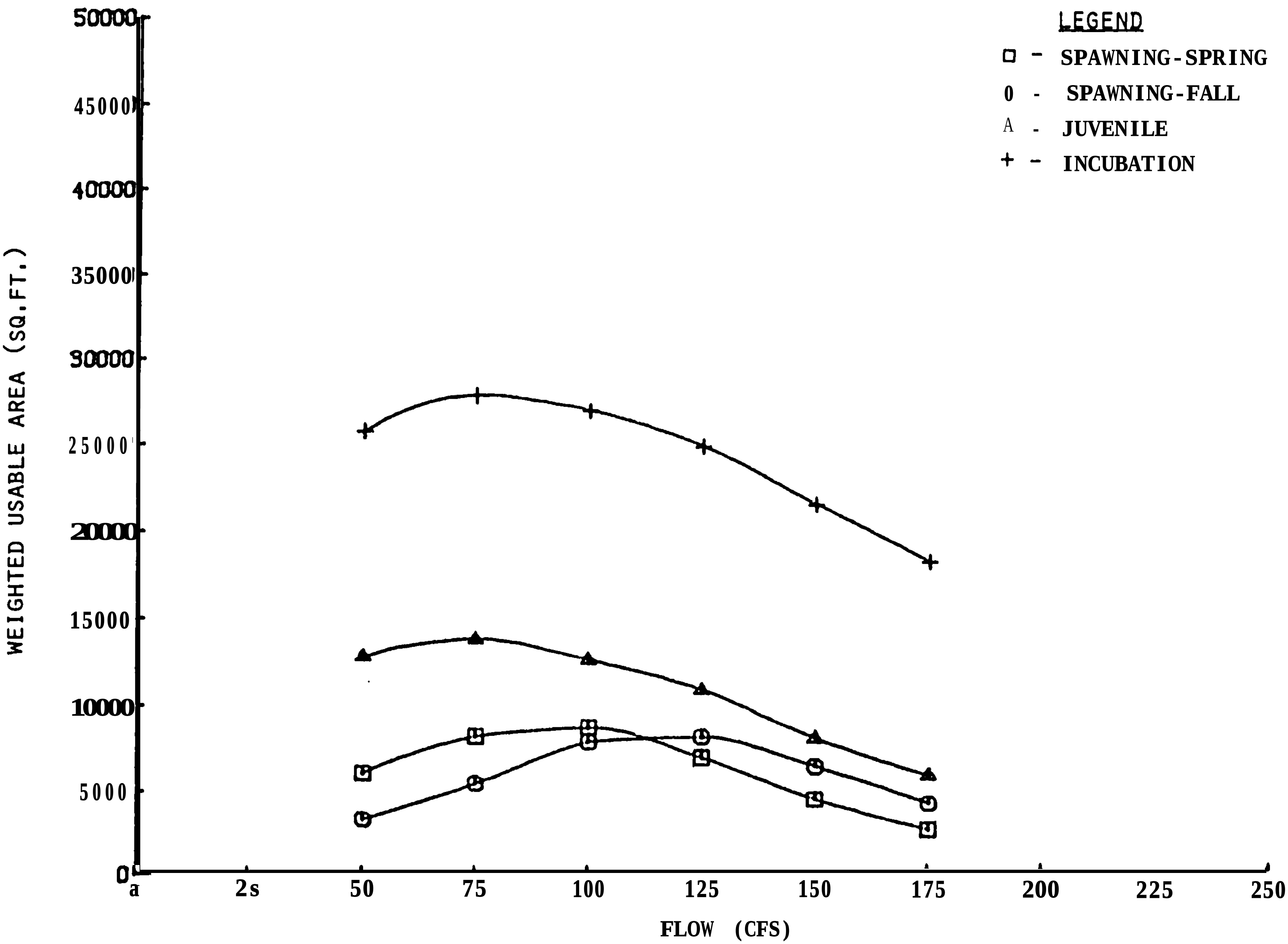


WARM. SPRINGS RIVER W-8



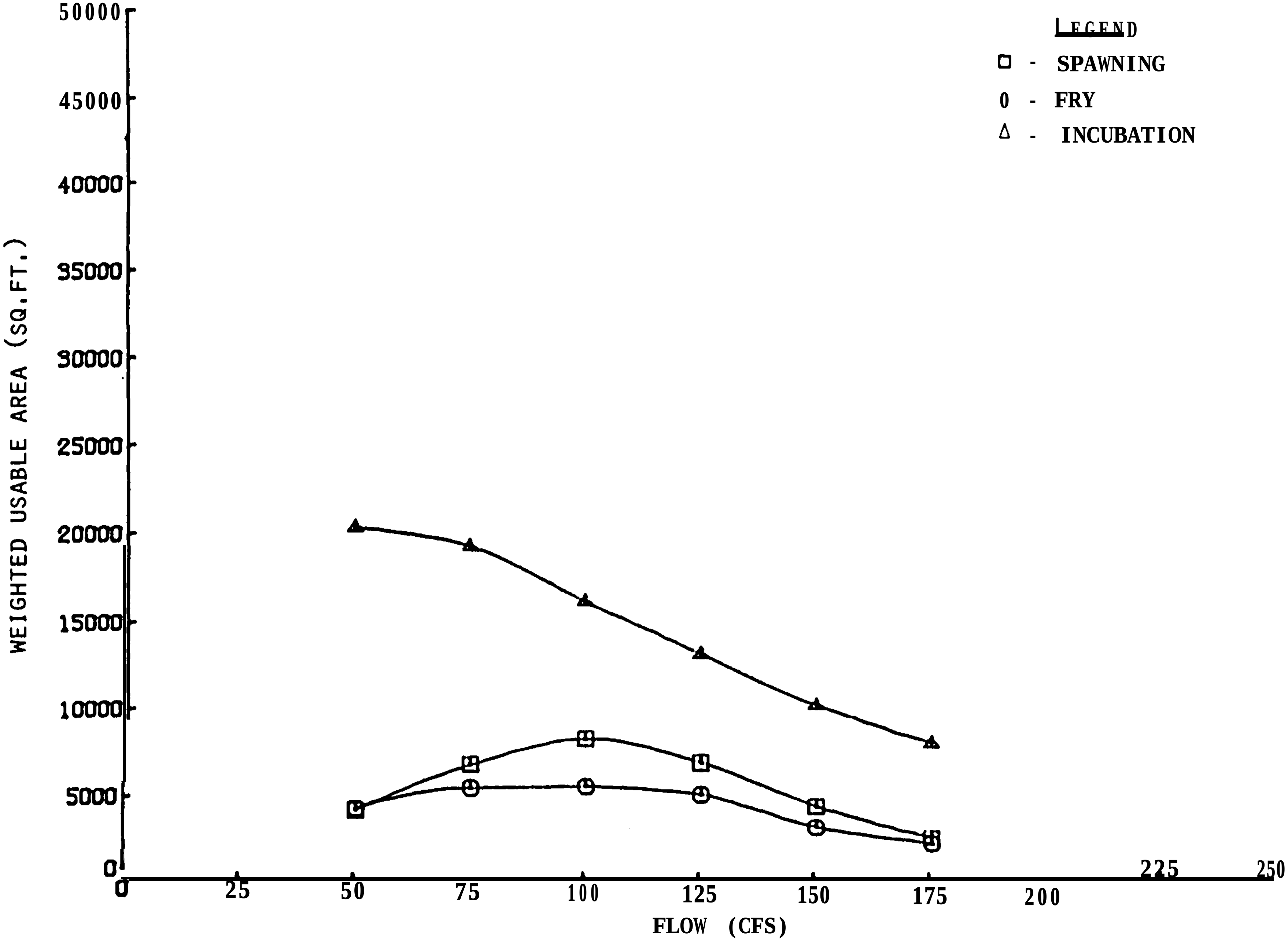
WARM SPRINGS RIVER W-8

STEELHEAD (CLEARWATER, .S = ,004)



WARM SPRINGS RIVER W-8

CHINOOK SALMON (CLEARWATER, S = ,004)



WARM SPRINGS RIVER W-8

COHO SALMON (CLEARWATER, S = ,004)

WARM SPRINGS RIVER (W-8)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.)
PER 1,000 FEET OF STREAM

STEELHEAD

DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
50	3136	2015	17955	21224	32437
75	6551	3810	20704	18942	38455
100	9552	3757	20749	15432	40849
125	11907	3286	18269	11320	41144
150	12517	3431	15544	8143	39412
175	12508	3189	12558	5760	36012

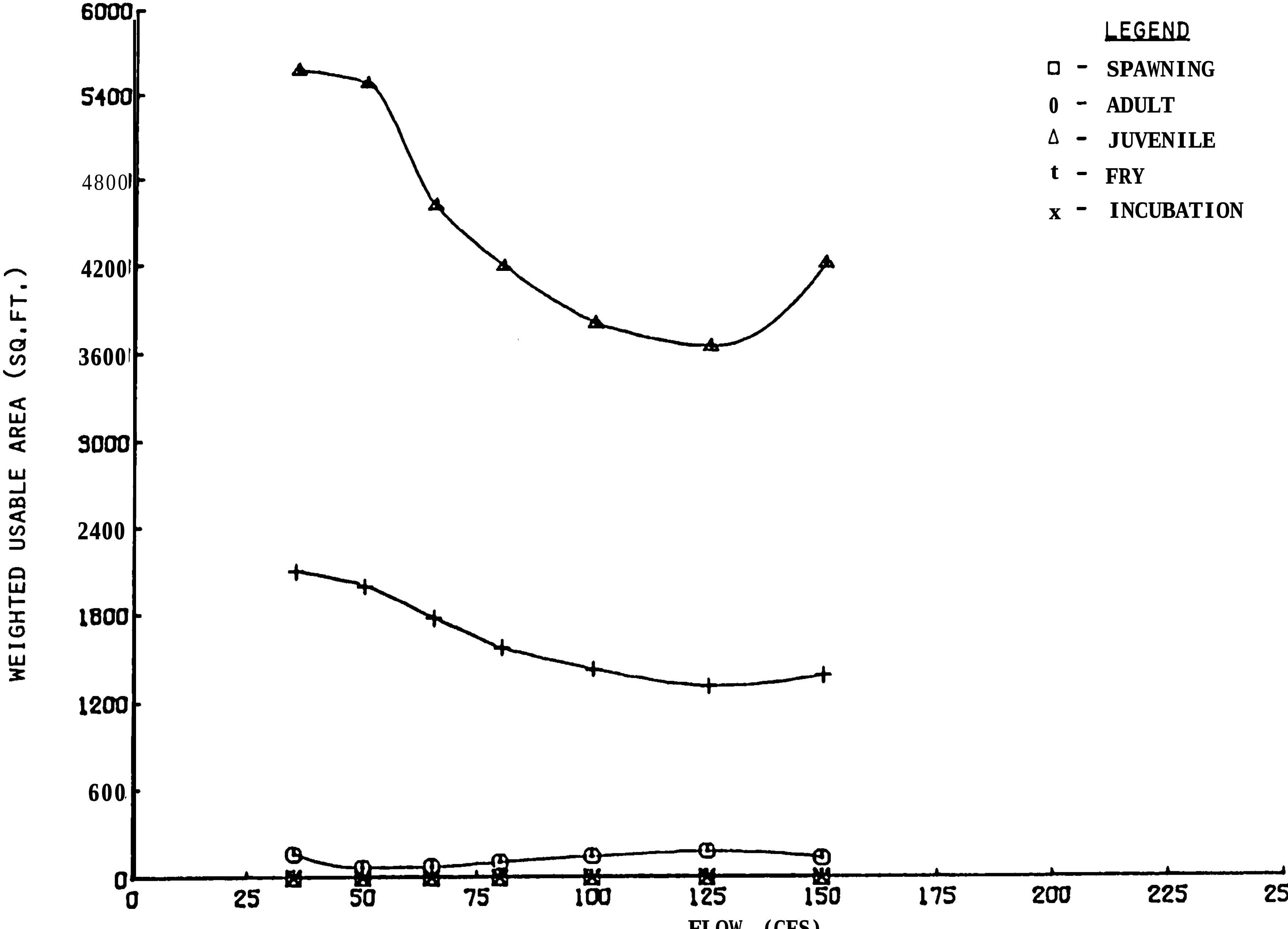
CHINOOK SALMON

DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
50	6021	3245	12747	25790
75	8149	5379	13718	27856
100	8591	7755	12450	26901
125	6804	7998	10702	24796
150	4309	6261	7894	21382
175	2406	4016	5708	18026

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
50	4126	4187	20334
75	6609	5291	19163
100	8016	5262	15941
125	6530	4705	12839
150	3923	2723	9759
175	1997	1694	7430

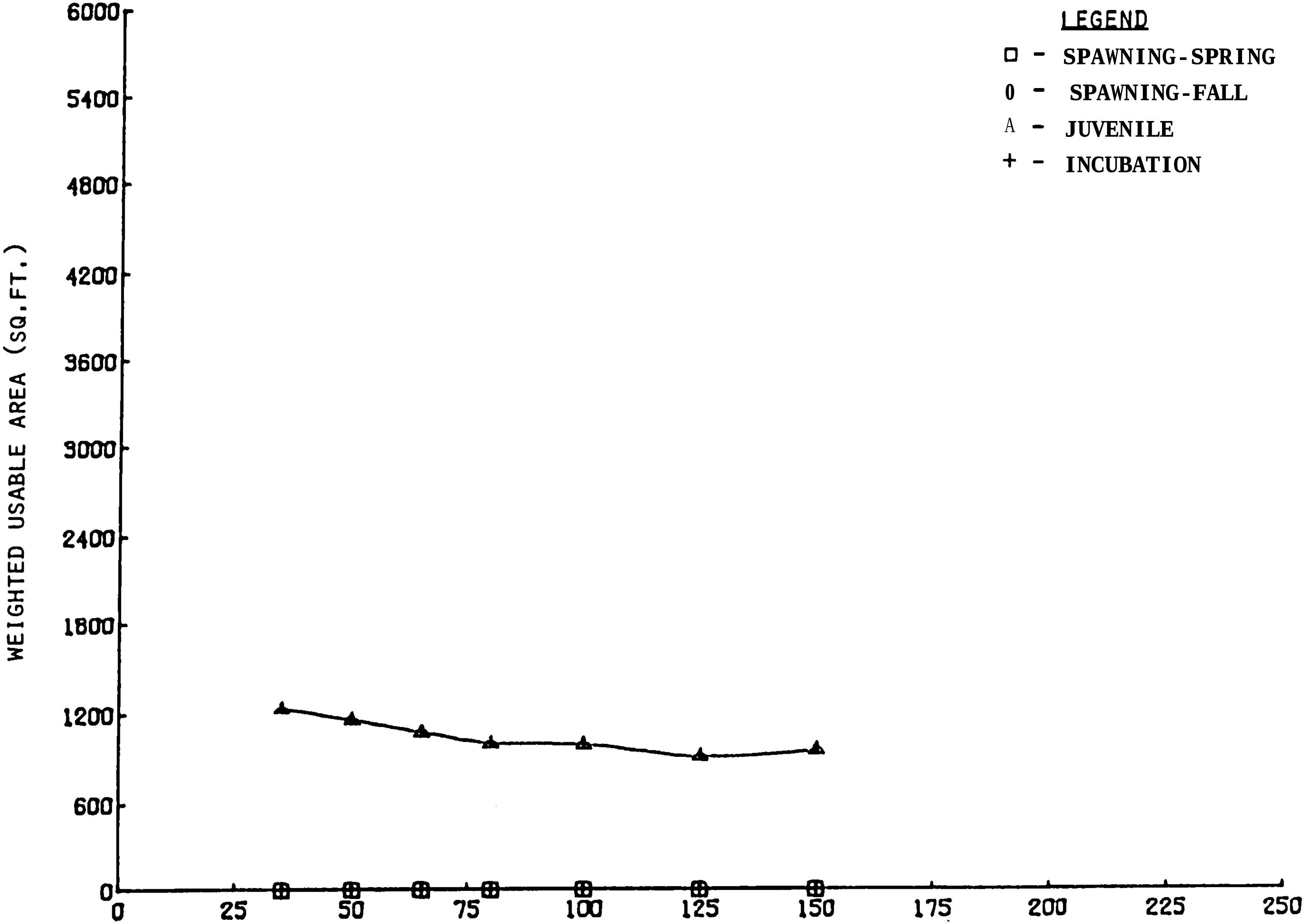
WARM SPRINGS RIVER W 9



WARM SPRINGS RIVER W-9

STEELHEAD (CLEARWATER, S = ,004)

NOTE: MANY OVERLAPPING SYMBOLS DUE TO LACK OF HABITAT,

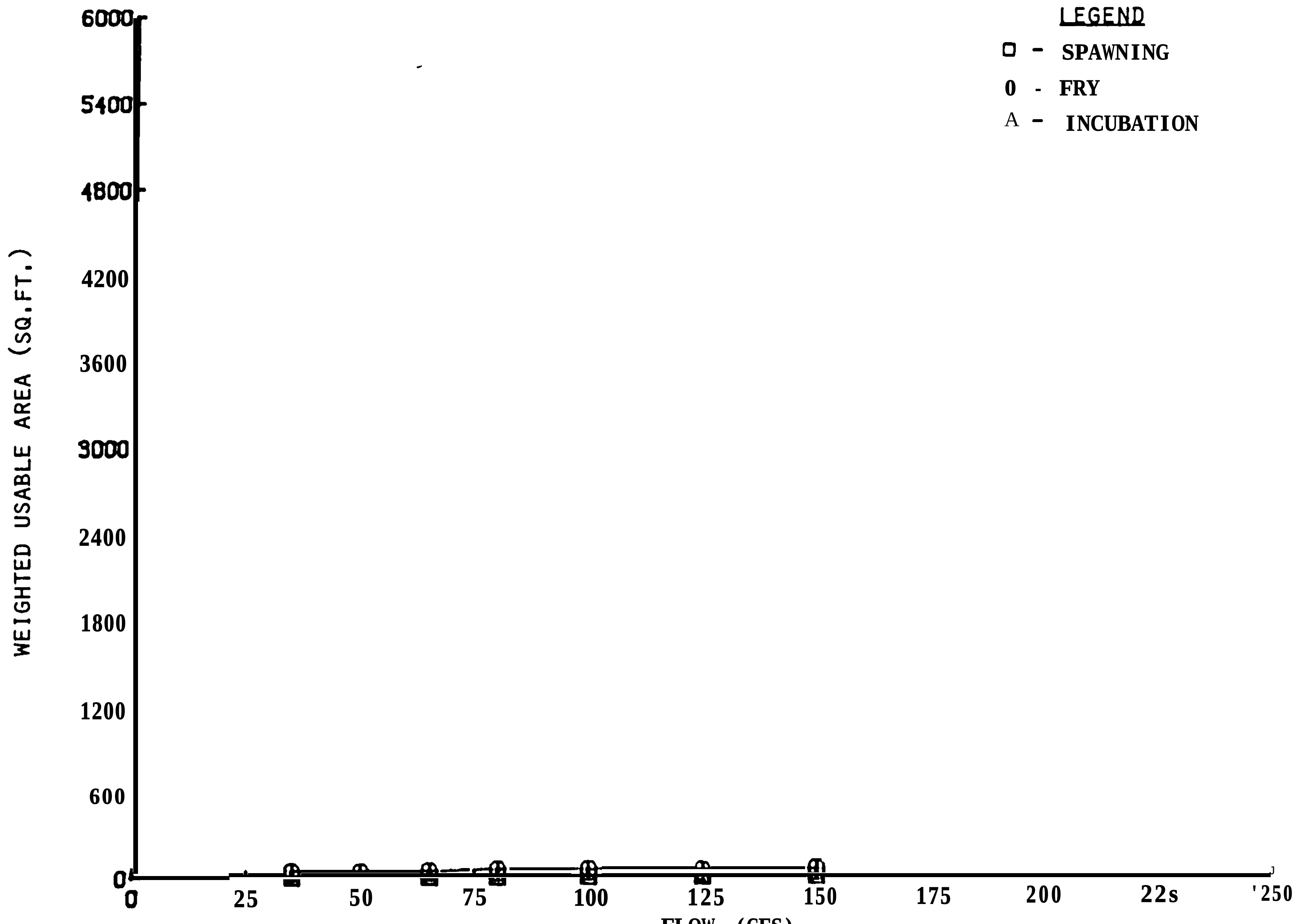


FLOW (CFS)

WARM SPRINGS RIVER W-9

CHINOOK SALMON (CLEARWATER, S = ,004)

NOTE: MANY OVERLAPPING SYMBOLS DUE TO LACK OF HABITAT,



WARM SPRINGS RIVER W-9

COHO SALMON (CLEARWATER, S = ,004)

NOTE: MANY OVERLAPPING SYMBOLS DUE TO LACK OF HABITAT,

WARM SRPINGS RIVER (W-9)

DISCHARGE (CFS) vs. AVAILABLE HABITAT AREA (SQ.FT.)
PER 1,000 FEET OF STREAM

STEELHEAD

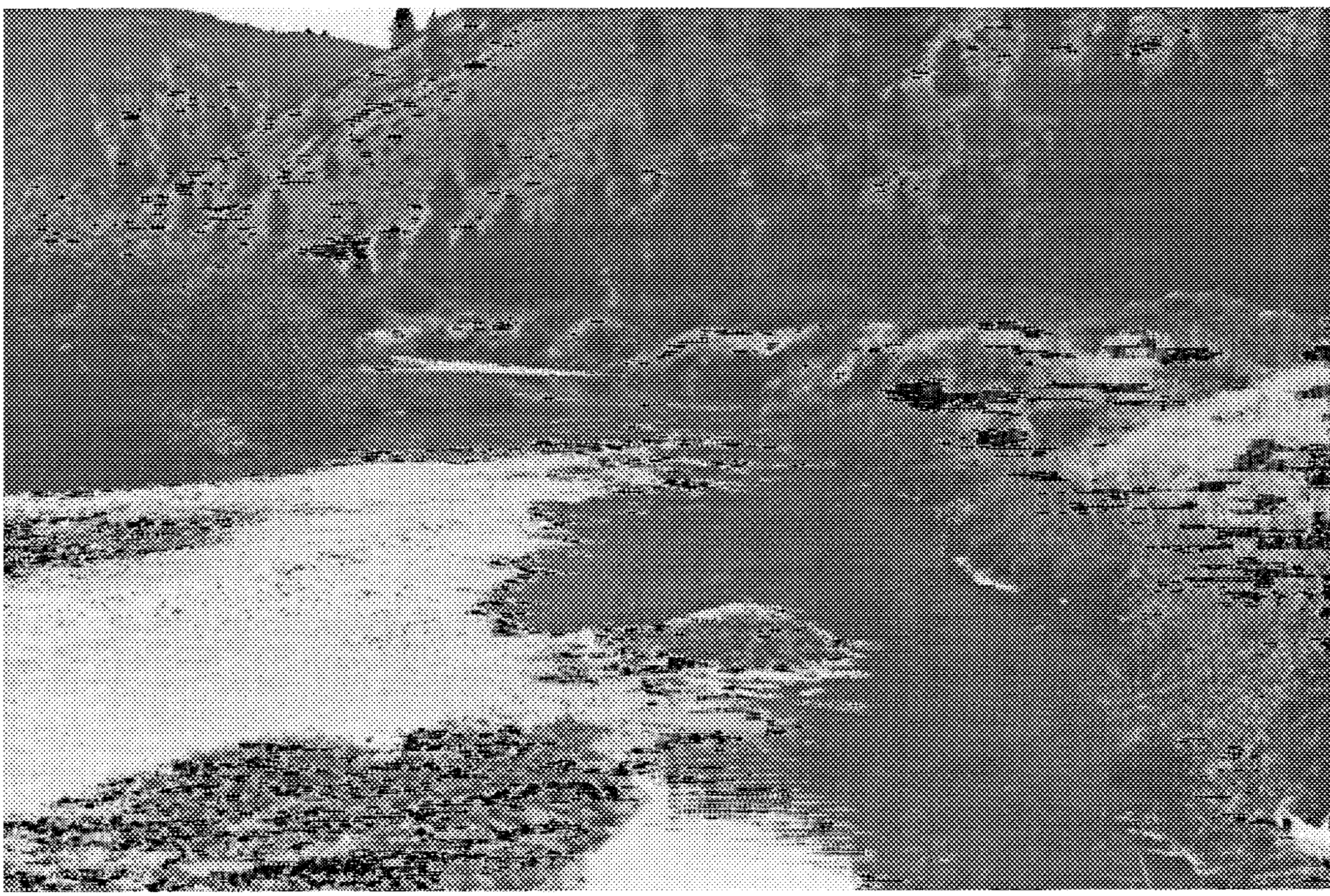
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
35	0	161	5572	2093	0
50	0	67	5480	1994	0
65	0	74	4611	1775	0
80	0	108	4194	1575	0
100	0	145	3806	1423	0
125	0	178	3651	1308	0
150	0	131	4211	1382	0

CHINOOK SALMON

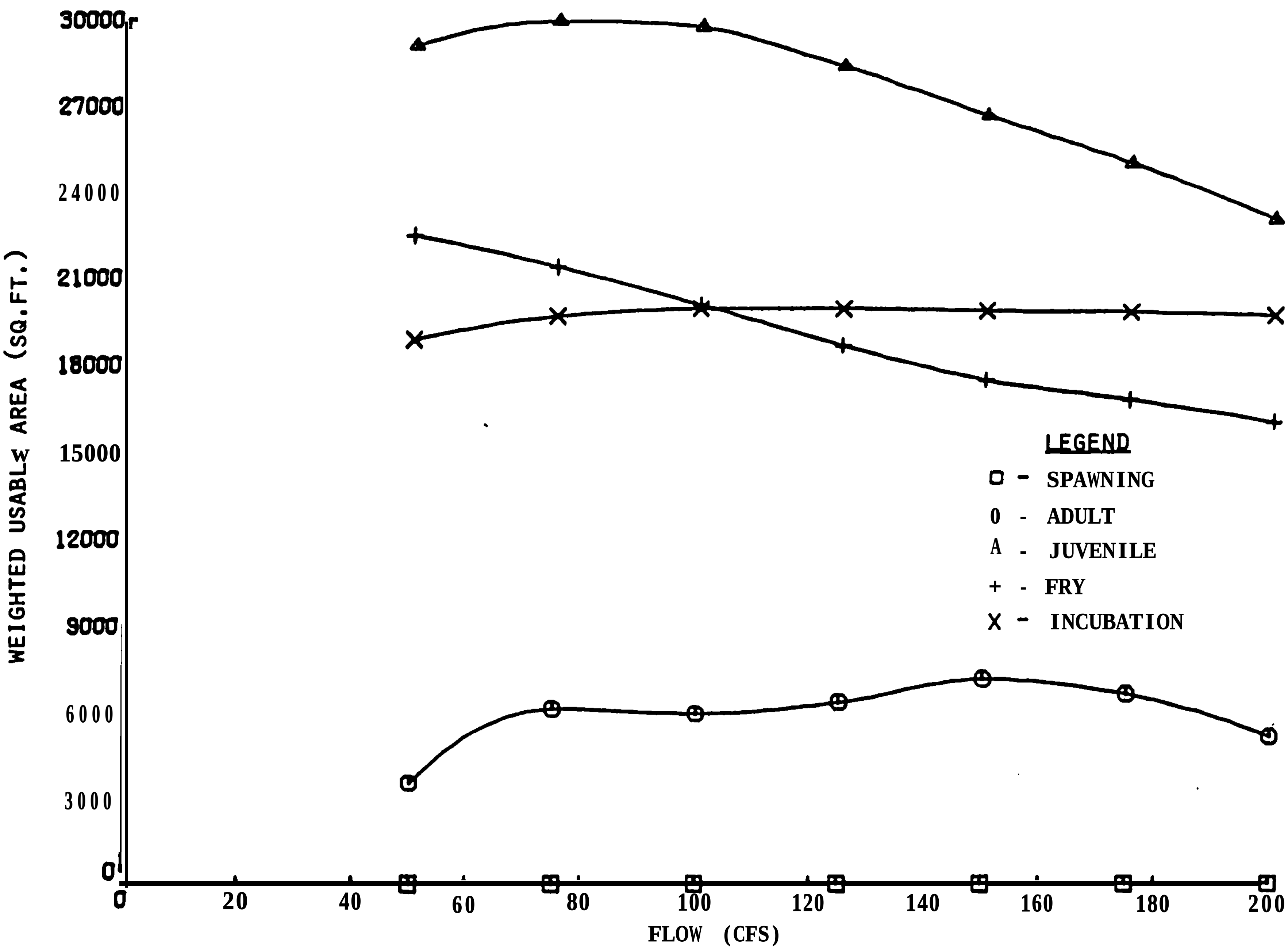
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
35	0	0	1240	0
50	0	0	1163	0
65	0	0	1079	0
80	0	0	1005	0
100		0	995	0
125	0	0	920	0
150	0	0	960	0

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
35	0	48	0
50	0	42	0
65	0	44	0
80	0	56	0
100	0	56	0
125	0	54	0
150	0	58	0

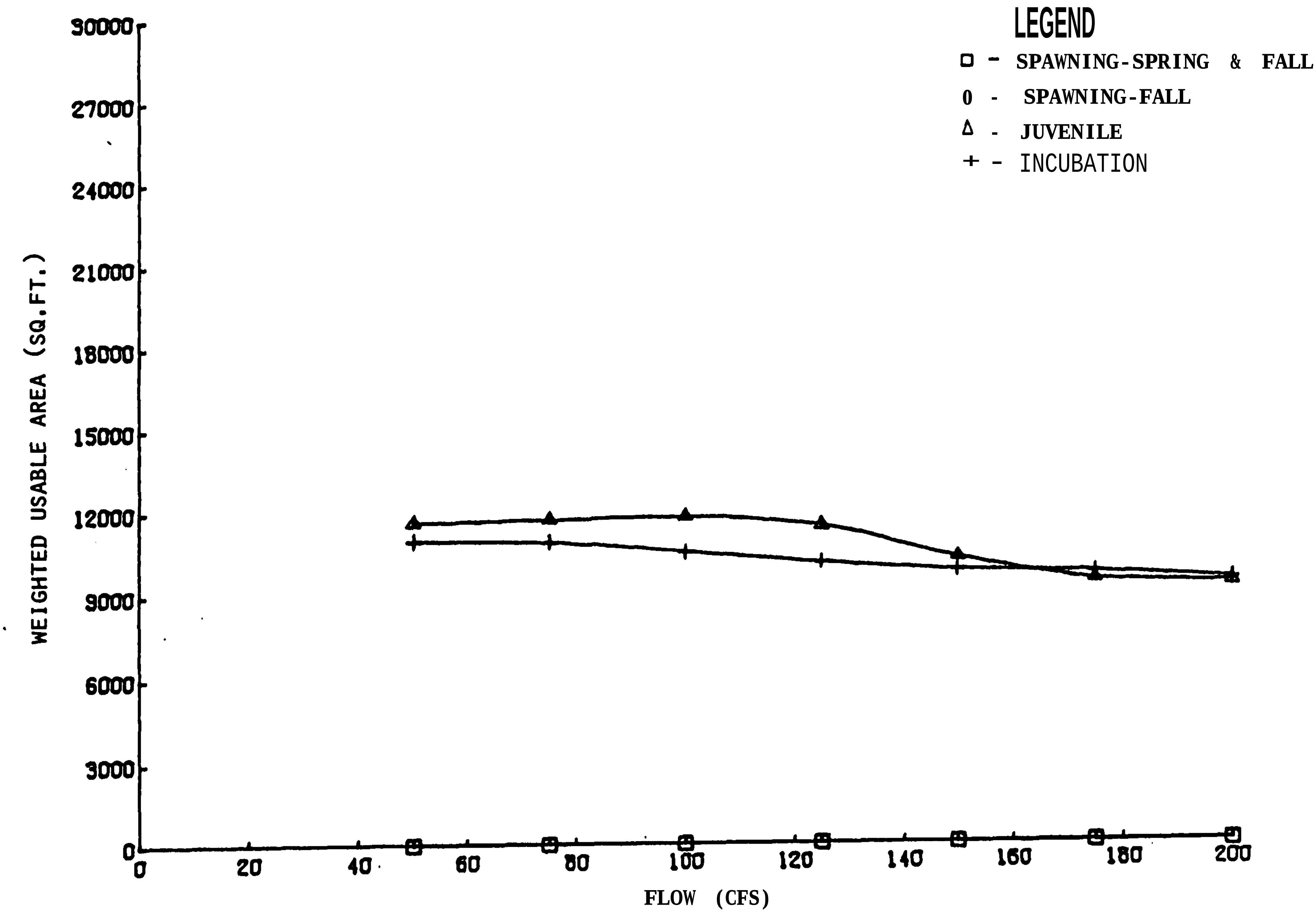


BEAVER CREEK B-1



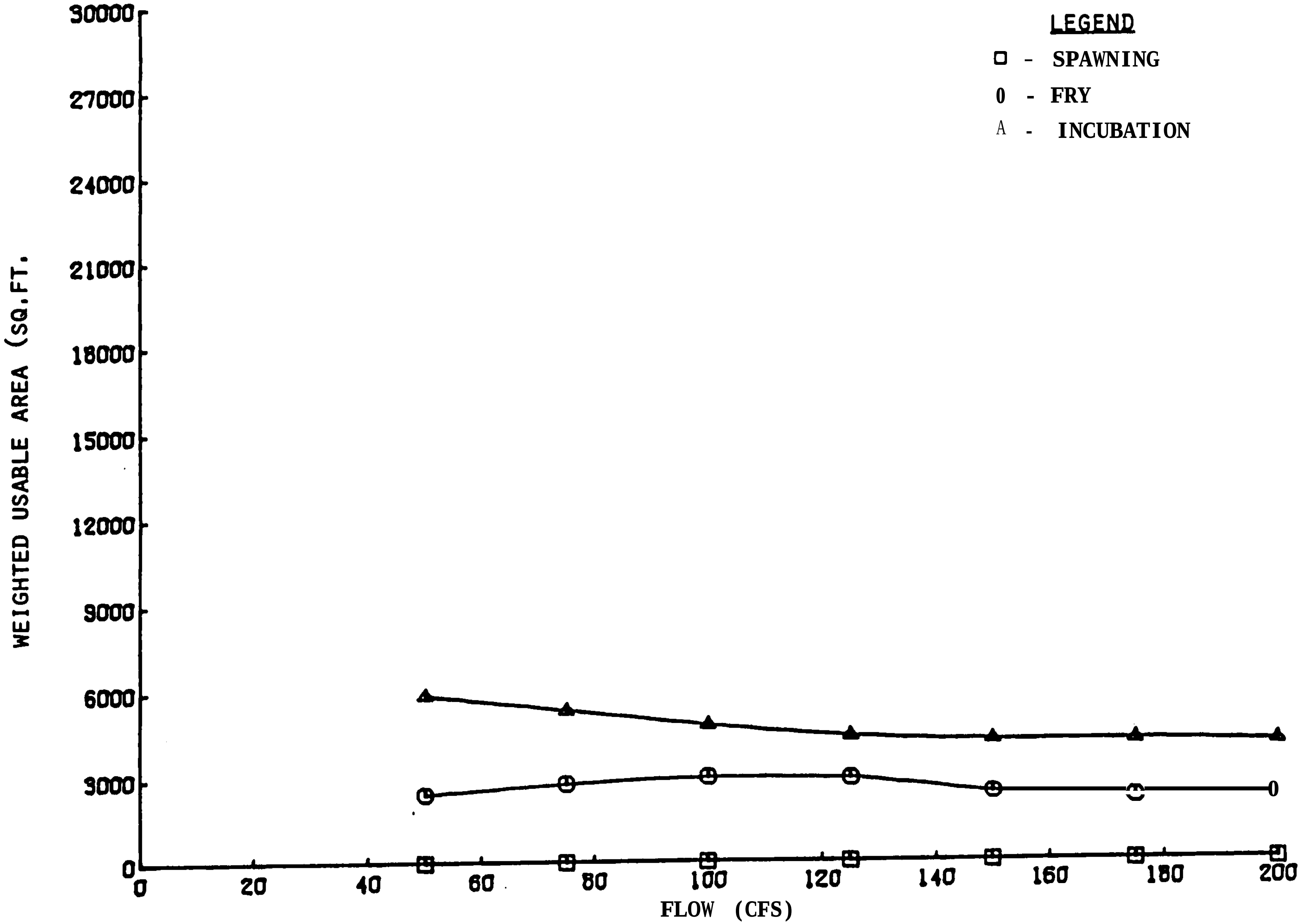
BEAVER CREEK B-1

STEELHEAD (CLEARWATER, S = .004)



BEAVER CREEK B-1

CHINOOK SALMON (CLEARWATER, S = .004)



BEAVER CREEK B-1

COHO SALMON (CLEARWATER, S = .004)

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BEAVER CREEK (B-l)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ. FT.) PER 1000 FEET OF STREAM

STEELHEAD

DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
50	0	3538	29 107	22461	18869
75	0	6082	29941	21379	19686
100	0	5879	29711	20047	19916
125	0	6274	28317	18638	19902
150	0	7063	26600	17428	19821
175	0	6520	24891	16747	19762
200	0	5026	22952	15969	19618

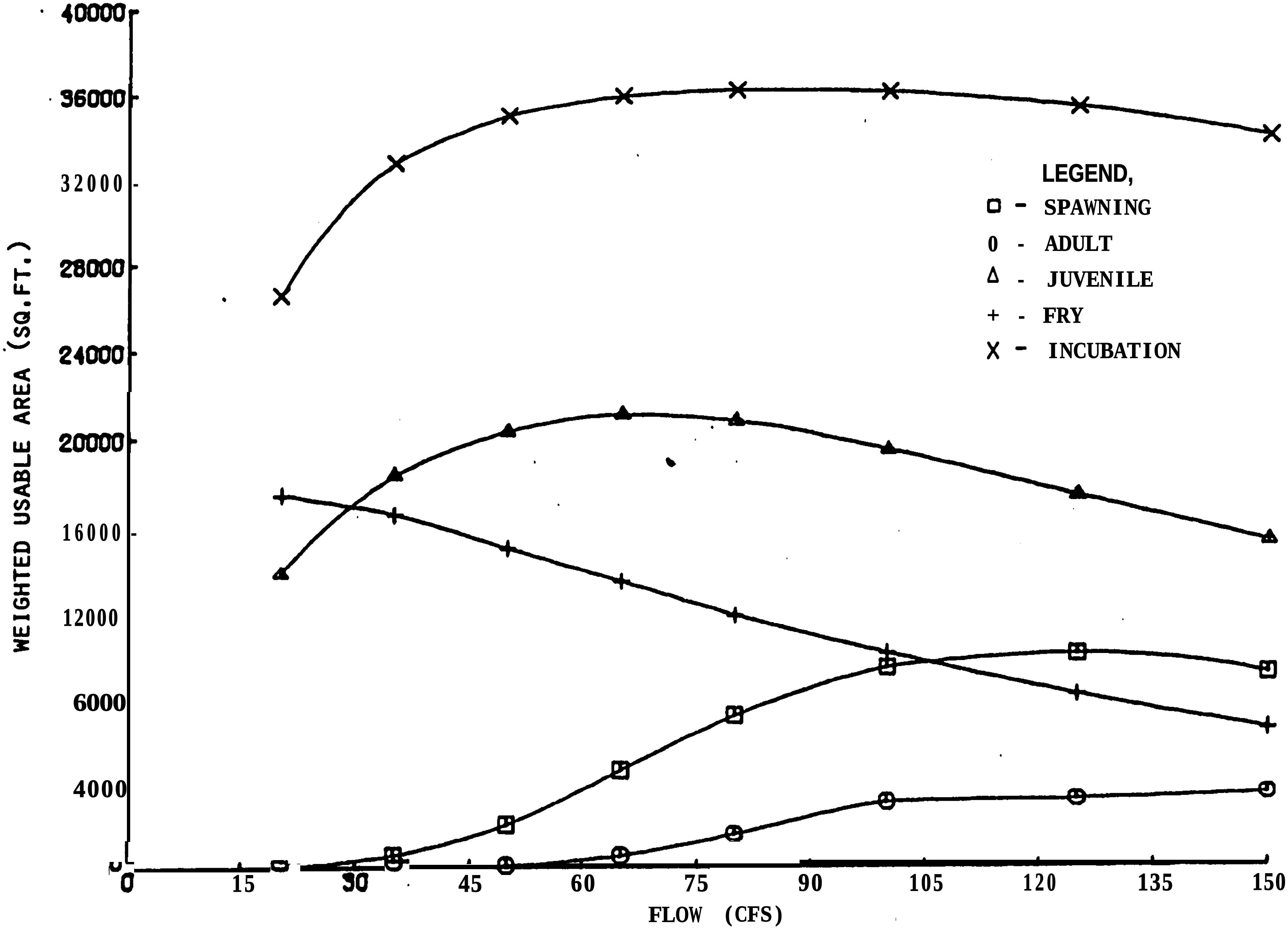
CHINOOK SALMON

DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
50	0	0	11614	10956
75	0	0	11726	10898
100	0	0	11799	10516
125	0	0	11438	10110
150	0	0	10259	9801
175	0	0	9441	9707
200	0	0	9305	9436

COHO SALMON

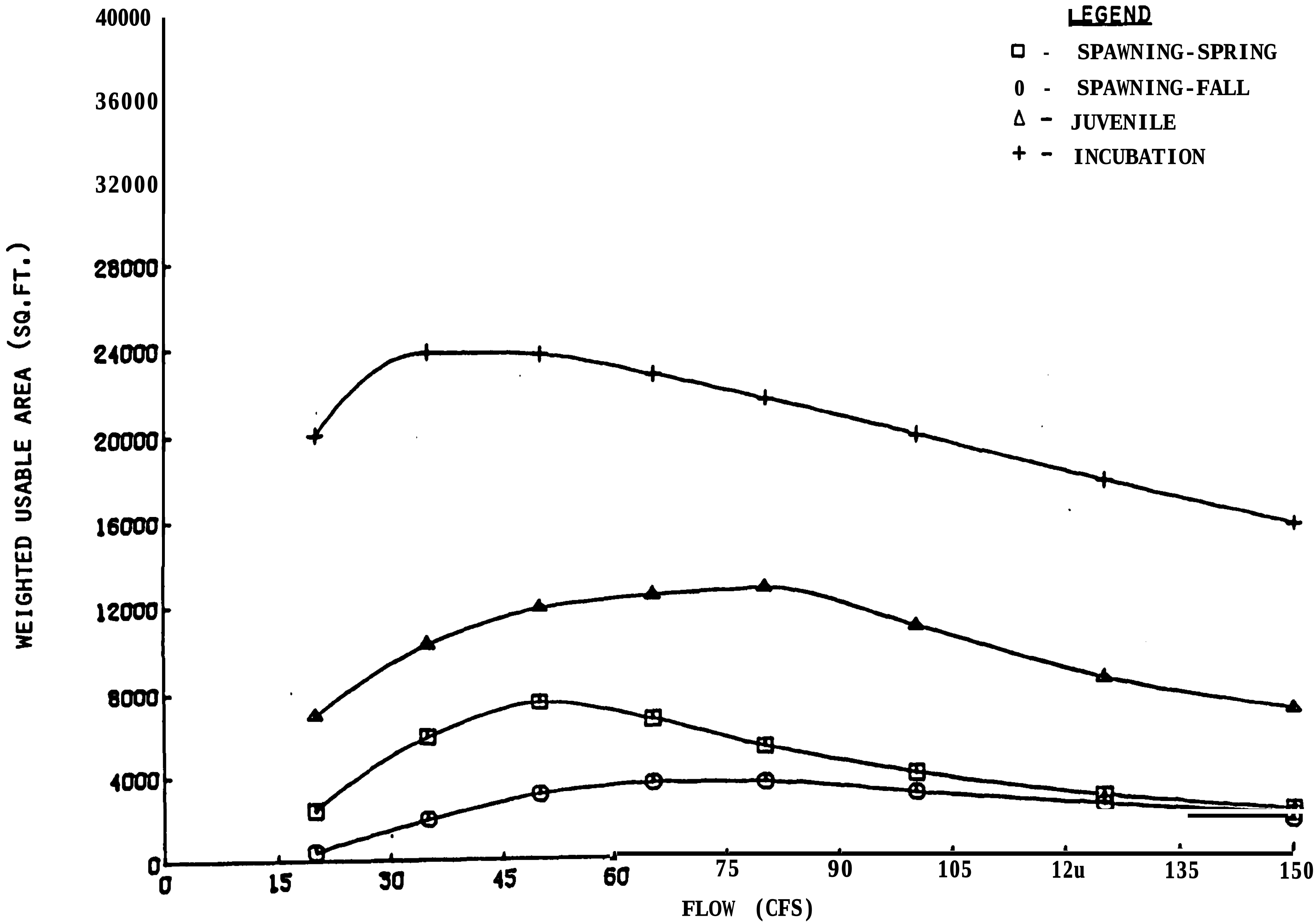
DISCHARGE	SPAWN1 NG	FRY	INCUBATION
50	0	2457	5880
75	0	2814	5350
100	0	3027	4827
125	0	2953	4408
150	0	2441	4237
175	0	2230	4235
200	0	2326	4154

BEAVER CREEK B-2



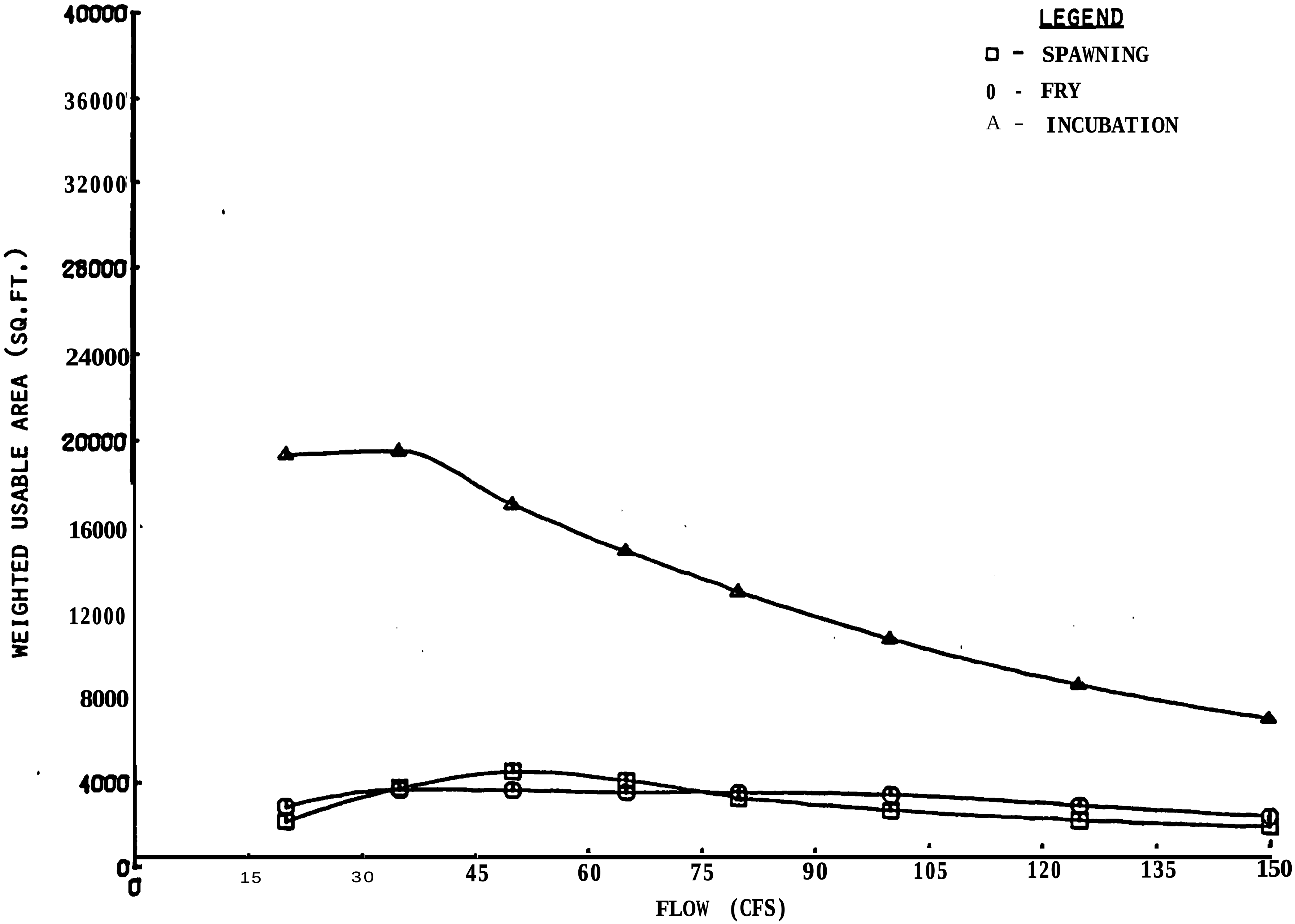
BEAVER CREEK B-2

STEELHEAD (CLEARWATER, S = .004)



BEAVER CREEK B-2

CHINOOK SALMON (CLEARWATER, S = .004)



BEAVER CREEK B-2

COHO SALMON (CLEARWATER, S = ,004)

BEAVER CREEK (B-2)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ. FT.) PER 1000 FEET OF STREAM

STEELHEAD

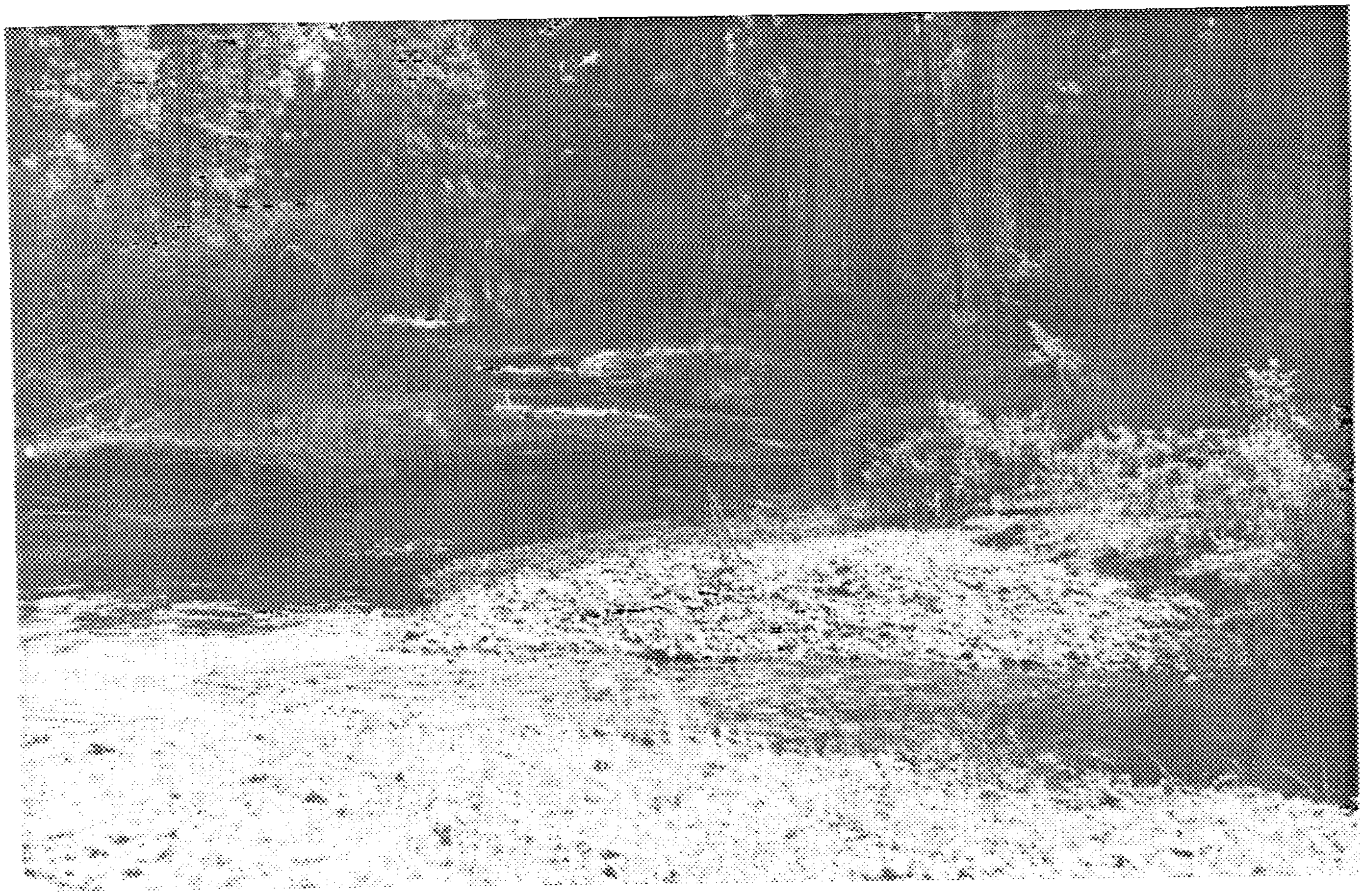
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
20	43	1	13830	17498	26631
35	600	17	18399	16574	32751
50	2029	117	20379	14979	34997
65	4583	562	21137	13397	35894
80	7148	1545	20828	11826	36177
100	9355	3035	19489	10019	36063
125	9979	3163	17373	8086	35333
150	9070	3451	15234	6488	33955

CHINOOK SALMON

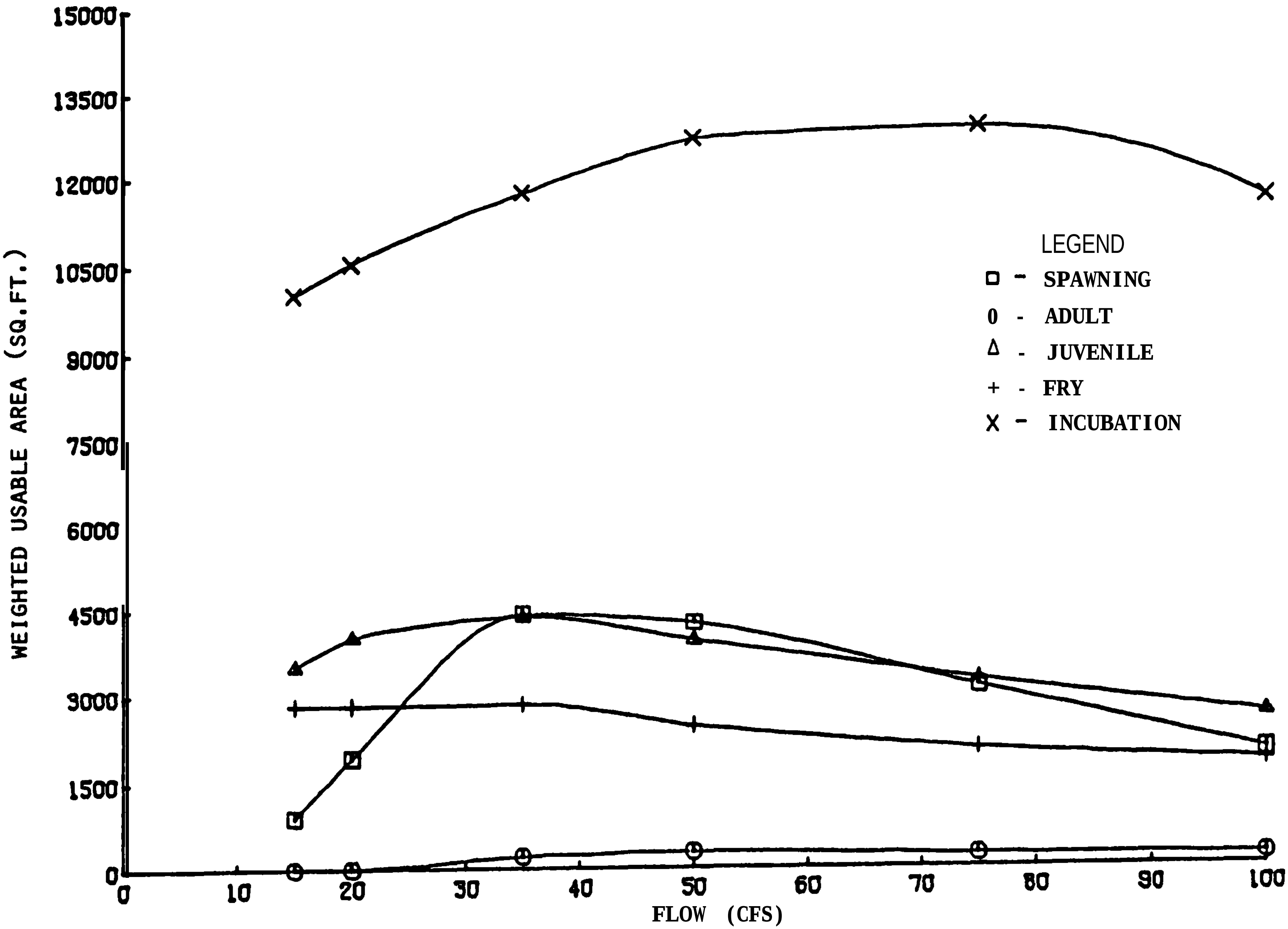
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
20	2394	435	6944	20127
35	5881	1922	10233	23862
50	7477	3087	11843	23732
65	6590	3543	12353	22736
80	5166	3474	12574	21559
100	3757	2827	10680	19764
125	2541	2110	8172	17462
150	1724	1495	6540	15216

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
20	2039	2738	19221
35	3577	3491	19348
50	4271	3397	16799
65	3787	3238	14586
80	2939	3175	12648
100	2249	2991	10339
125	1662	2388	8042
150	1259	1770	6361

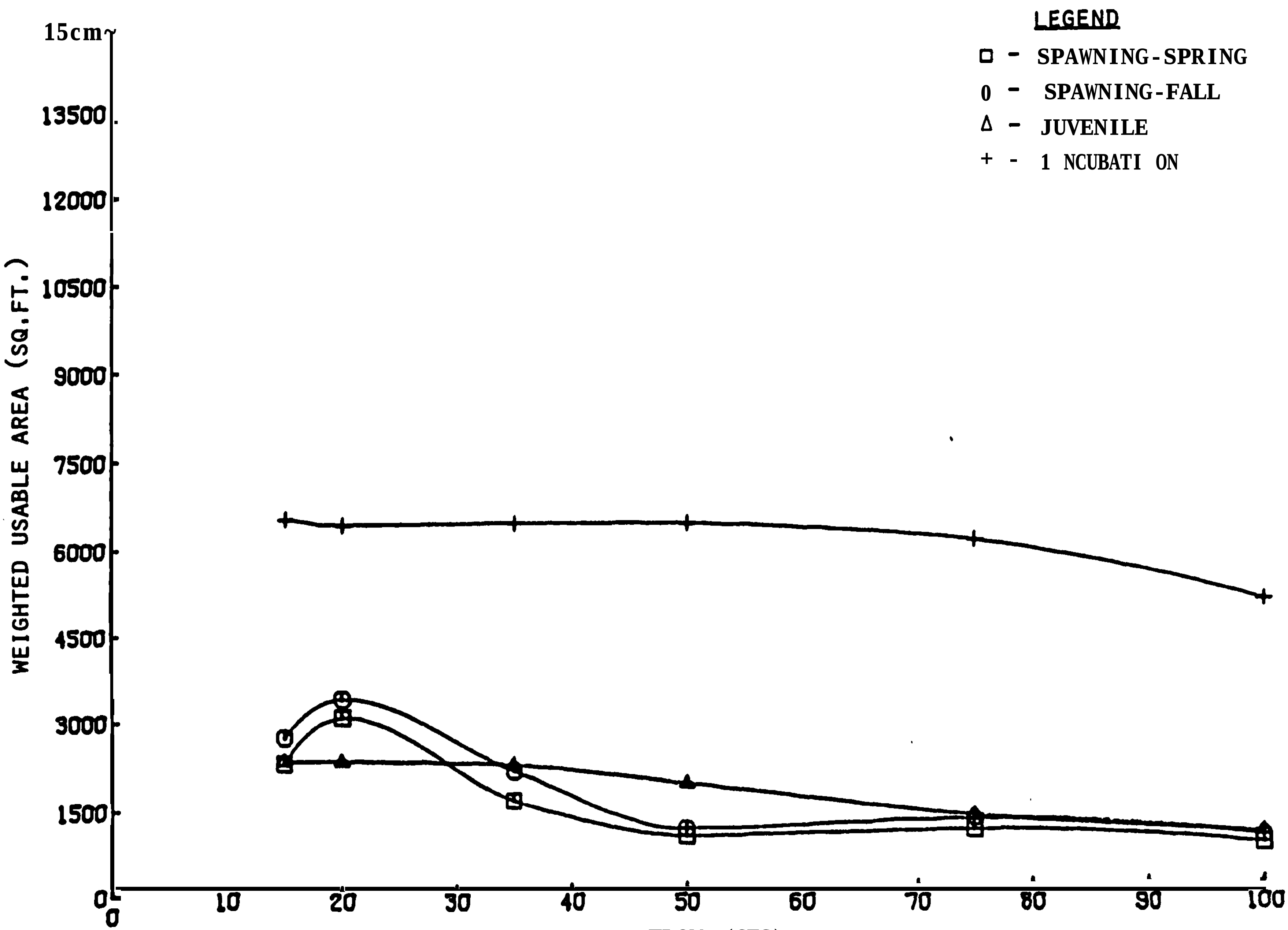


BEAVER CREEK B-3



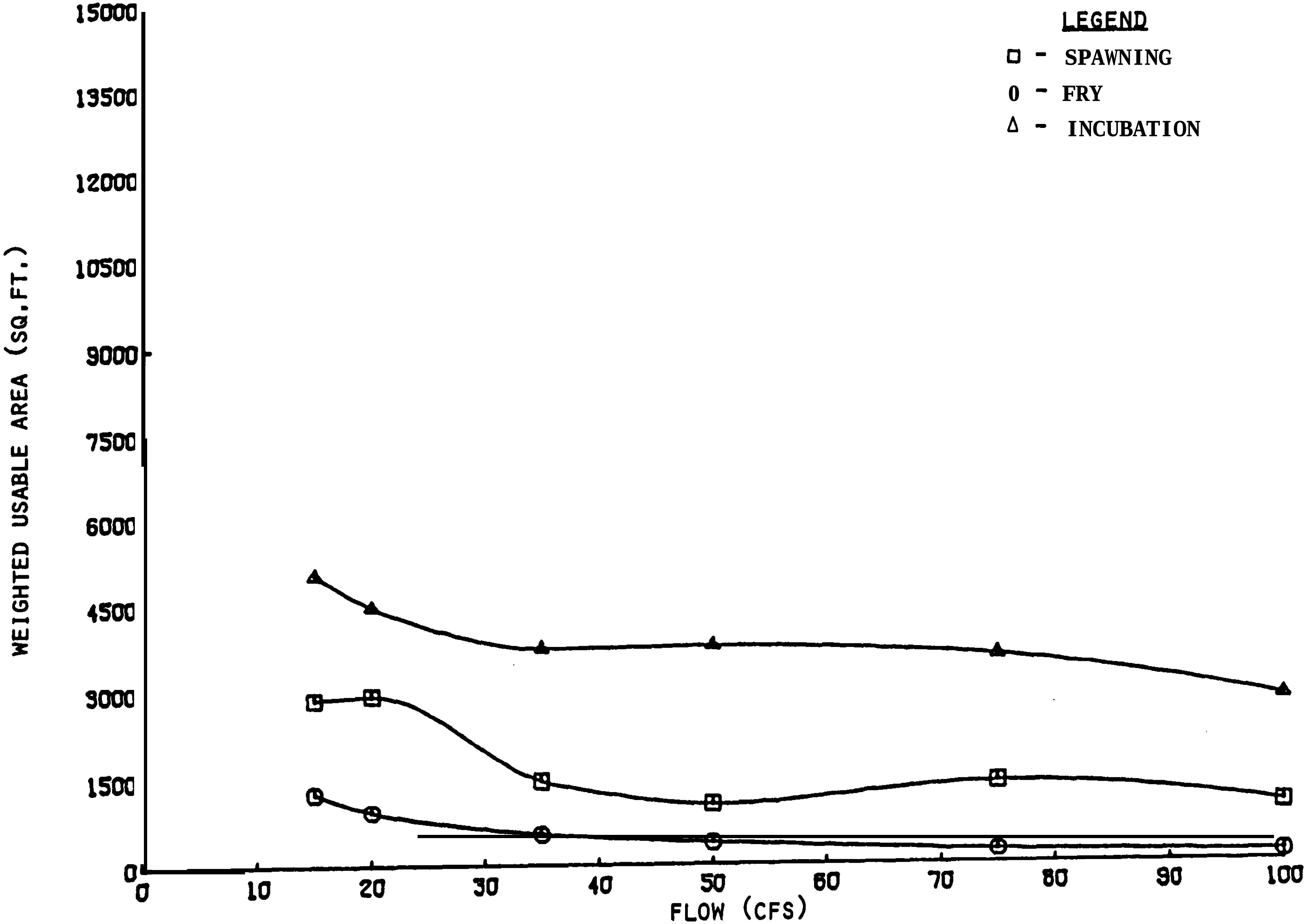
BEAVER CREEK B-3

STEELHEAD (CLEARWATER, S = ,004)



BEAVER CREEK B-3

CHINOOK SALMON (CLEARWATER, S = ,004)



BEAVER CREEK B-3

COHO SALMON (CLEARWATER, S = ,004)

BEAVER CREEK (B-3)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ. FT.) PER 1000 FEET OF STREAM

STEELHEAD

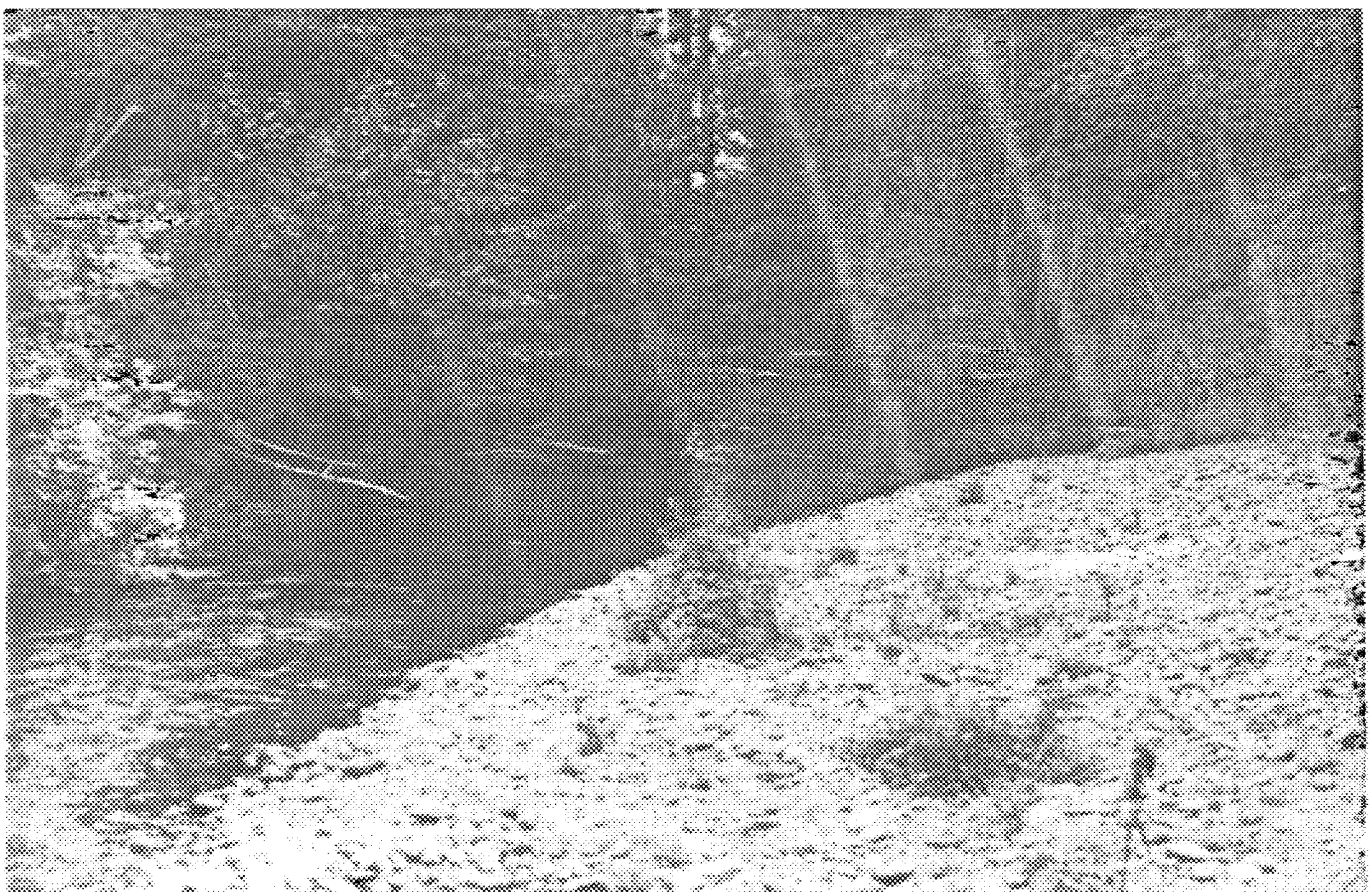
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
15	907	6	3504	2810	10020
20	1928	13	4017	2819	10552
35	4418	222	4376	2838	11754
50	4240	285	3946	2458	12684
75	3113	218	3244	2051	12857
100	1994	199	2613	1825	11610

CHINOOK SALMON

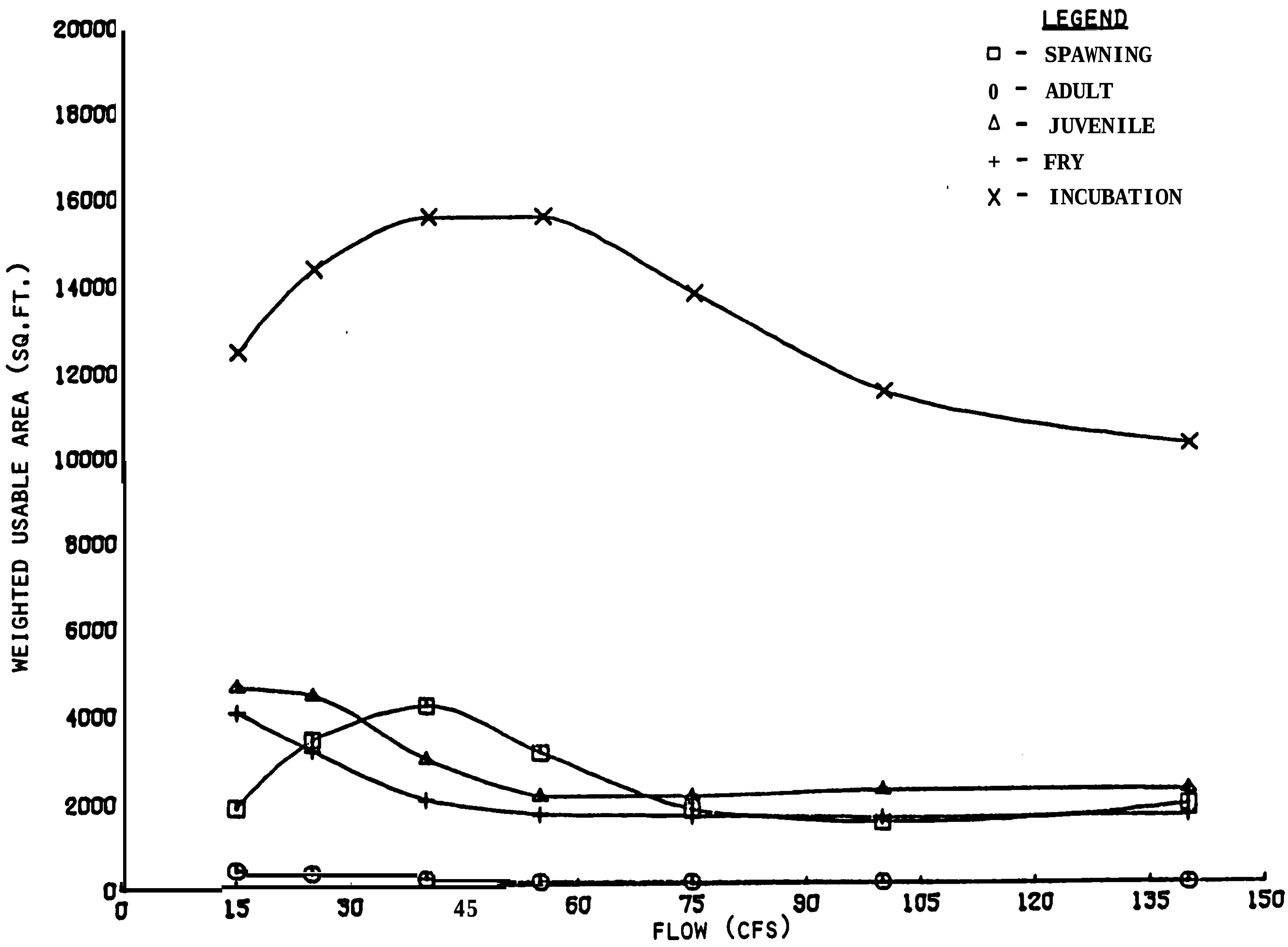
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
15	2260	2710	2303	6515
20	3038	3363	2285	6395
35	1595	2092	2199	6398
50	971	1088	1866	6377
75	1033	1223	1273	6027
100	759	889	951	4954

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
15	2878	1263	5042
20	2947	944	4481
35	1454	552	3758
50	1059	397	3795
75	1418	235	3603
100	1029	179	2844

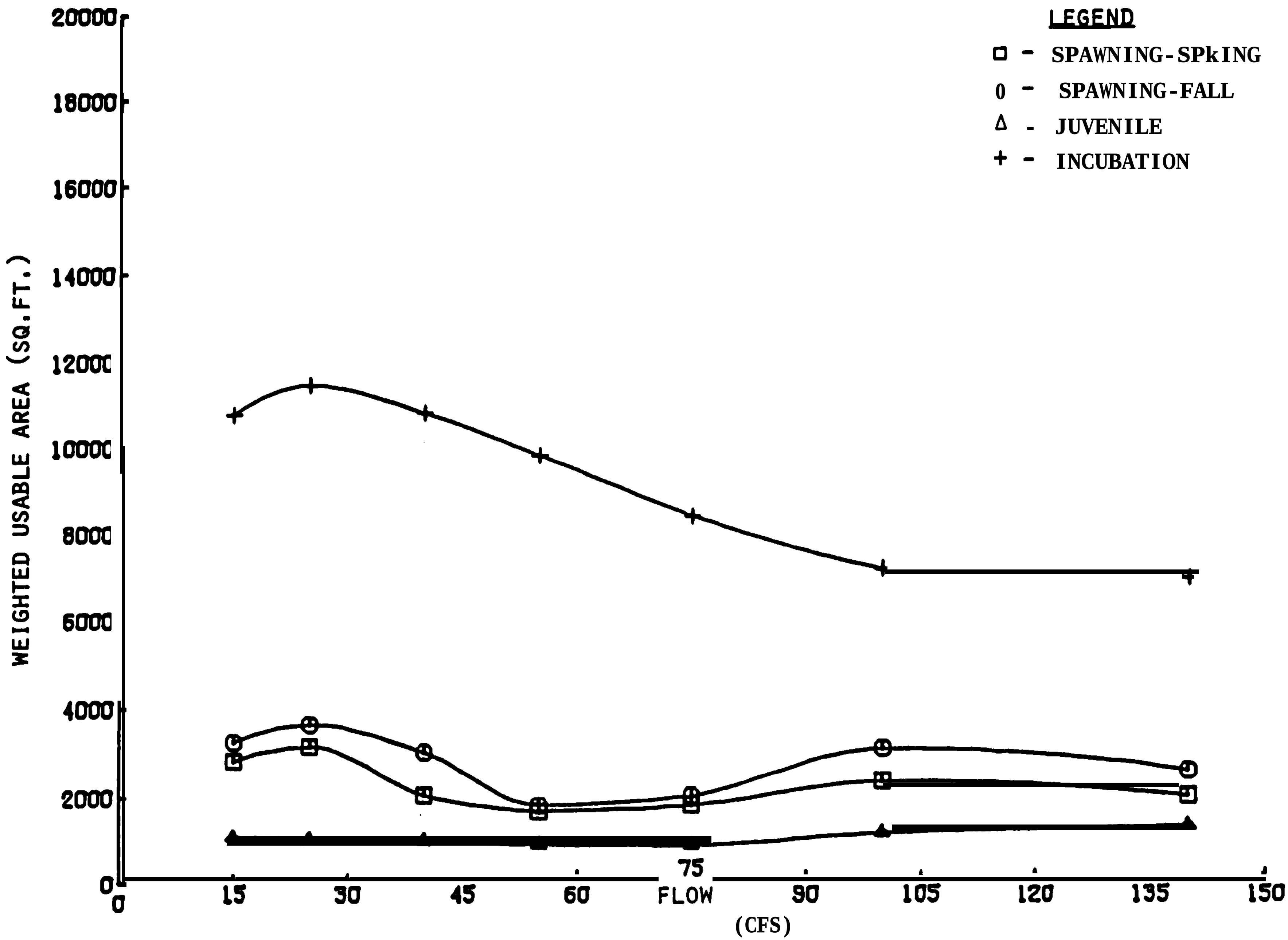


BEAVER CREEK B-4



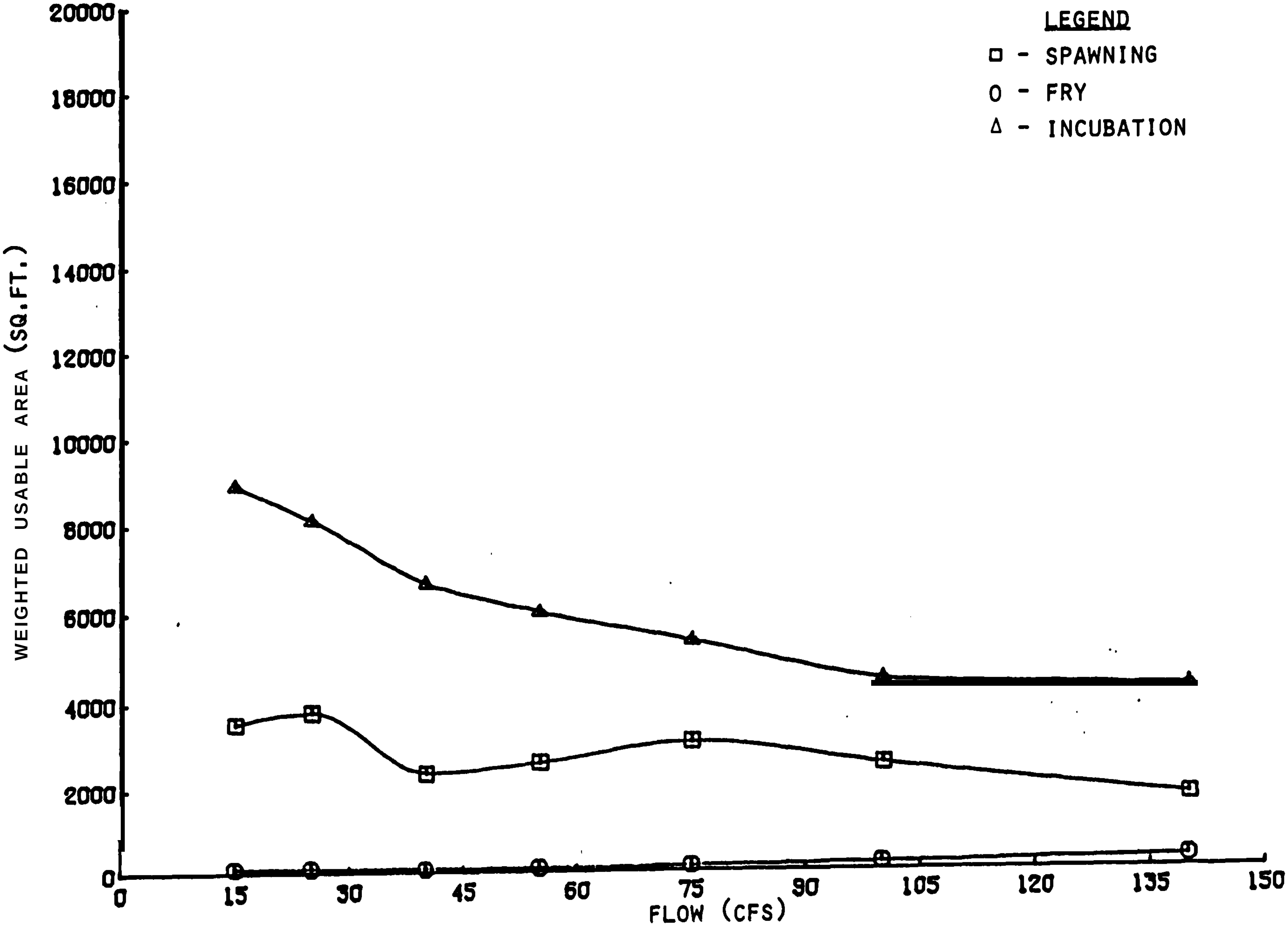
BEAVER CREEK B-4

STEELHEAD (CLEARWATER, S = ,004)



BEAVER CREEK B-4

CHINOOK SALMON (CLEARWATER, S = ,004)



BEAVER CREEK B-4

COHO SALMON (CLEARWATER, S = .004)

BEAVER CREEK (B-2)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ. FT.)
PER 1000 FEET OF STREAM

STEELHEAD

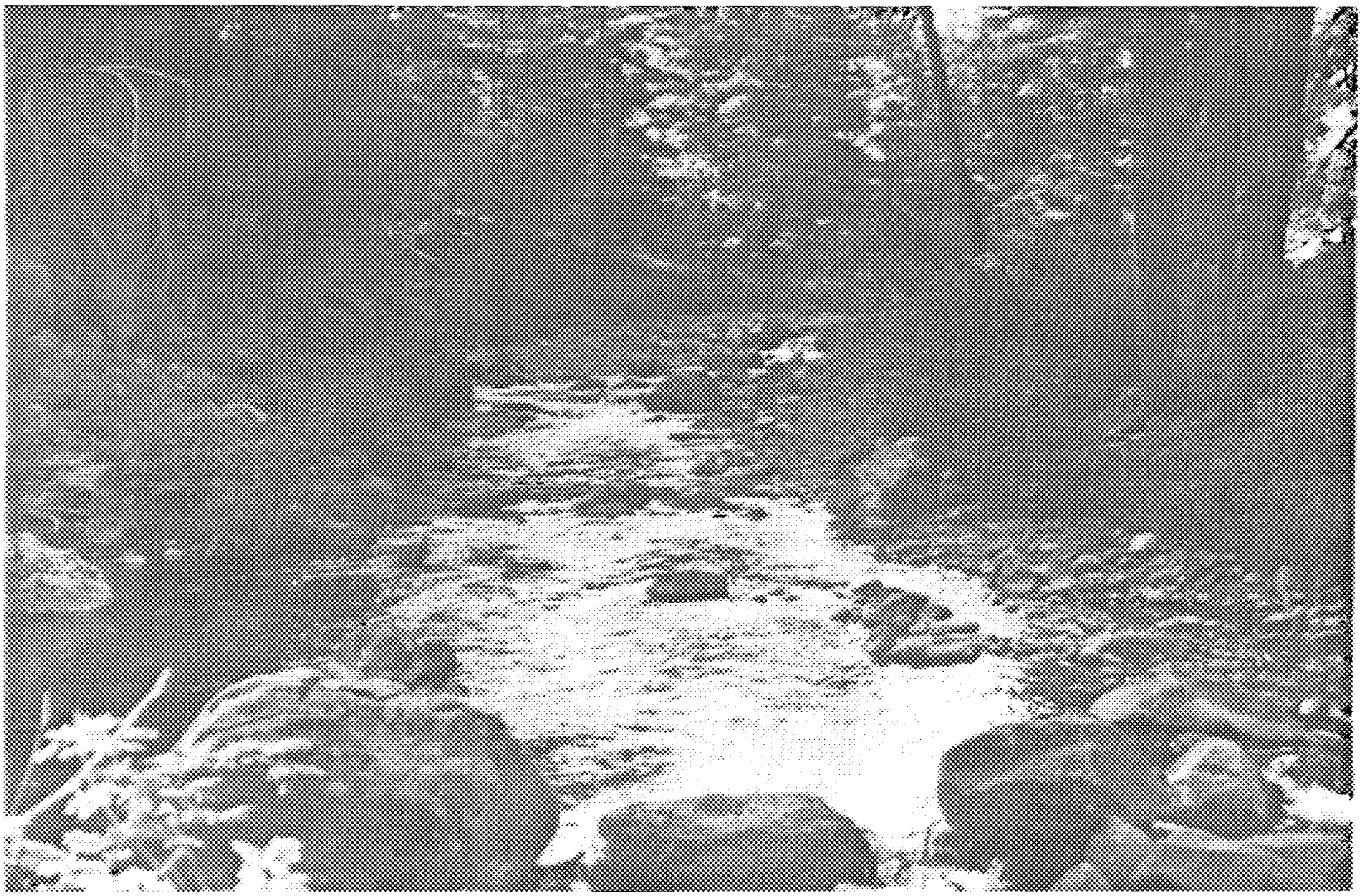
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
20	43	1	13830	17498	26631
35	600	17	18399	16574	32751
50	2029	117	20379	14979	34997
65	4583	562	21137	13397	35894
80	7148	1545	20828	11826	36177
100	9355	3035	19489	10019	36063
125	9979	3163	17373	8086	35333
150	9070	3451	15234	6488	33955

CHINOOK SALMON

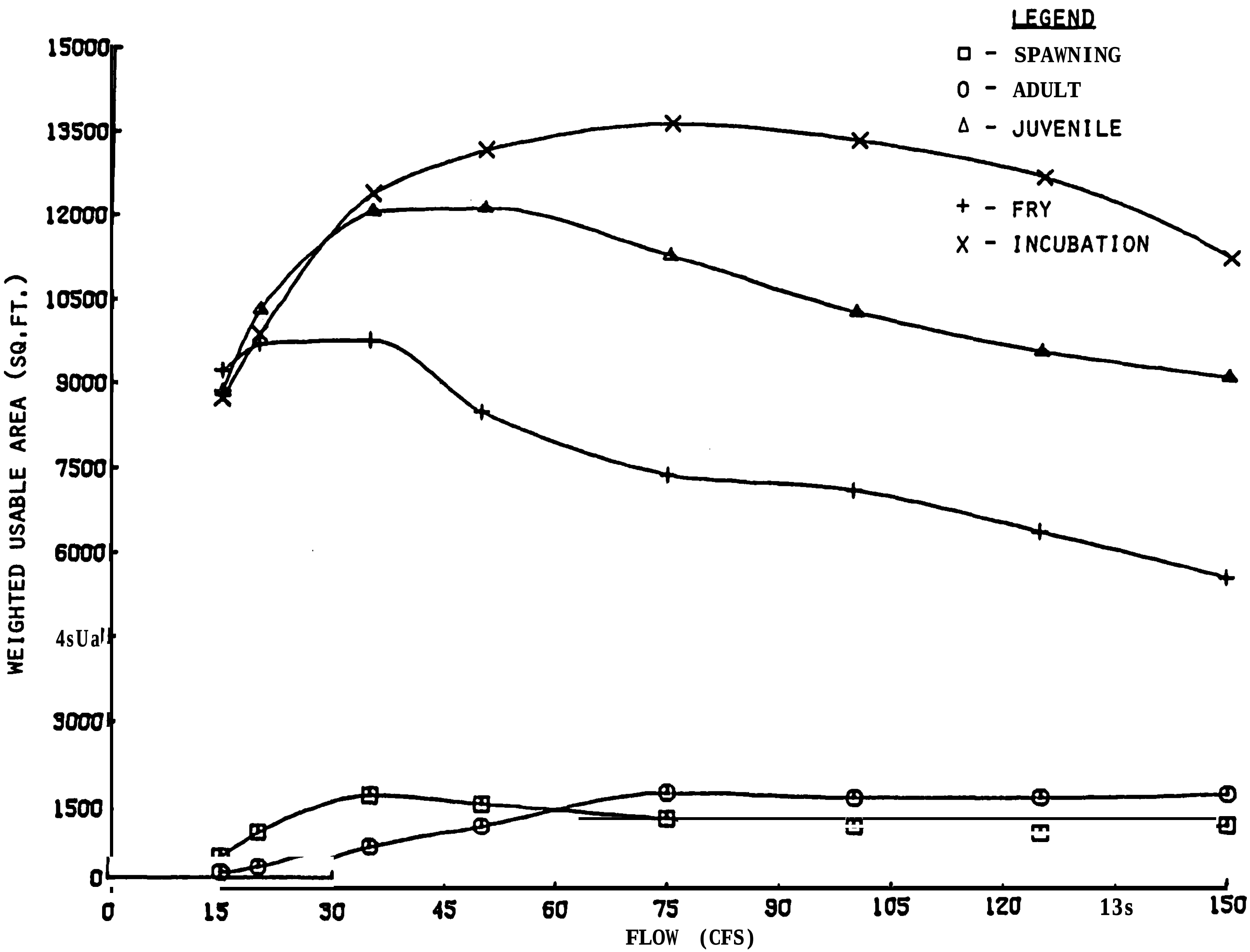
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
20	2394	435	6944	20127
35	5881	1922	10233	23862
50	7477	3087	11843	23732
65	6590	3543	12353	22736
80	5166	3474	12574	21559
100	3757	2827	10680	19764
125	2541	2110	8172	17462
150	1724	1495	6540	15216

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
20	2039	2738	19221
35	3577	3491	19348
50	4271	3397	16799
65	3787	3238	14586
80	2939	3175	12648
100	2249	2991	10339
125	1662	2388	8042
150	1259	1770	6361

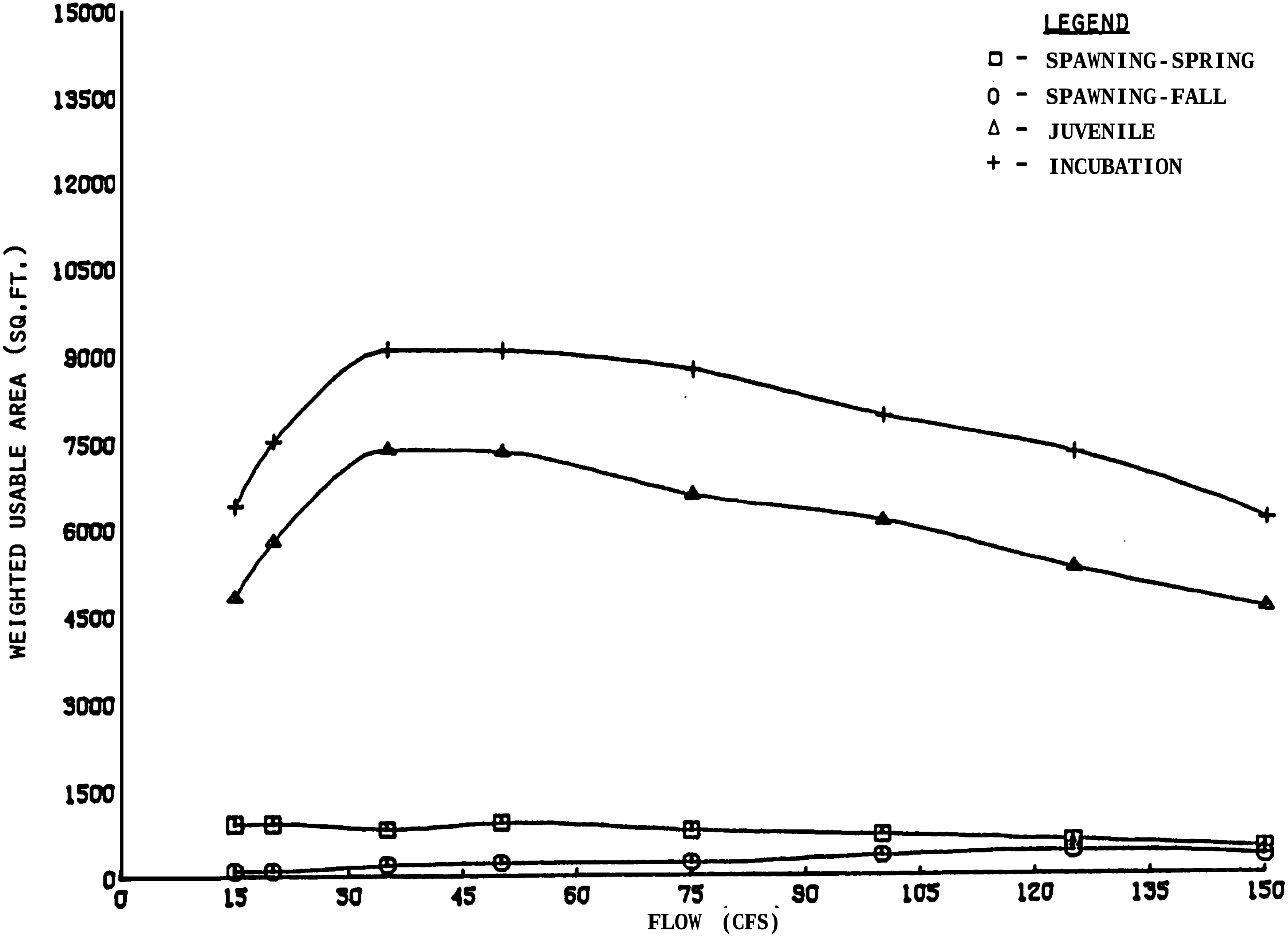


MILL CREEK M-1



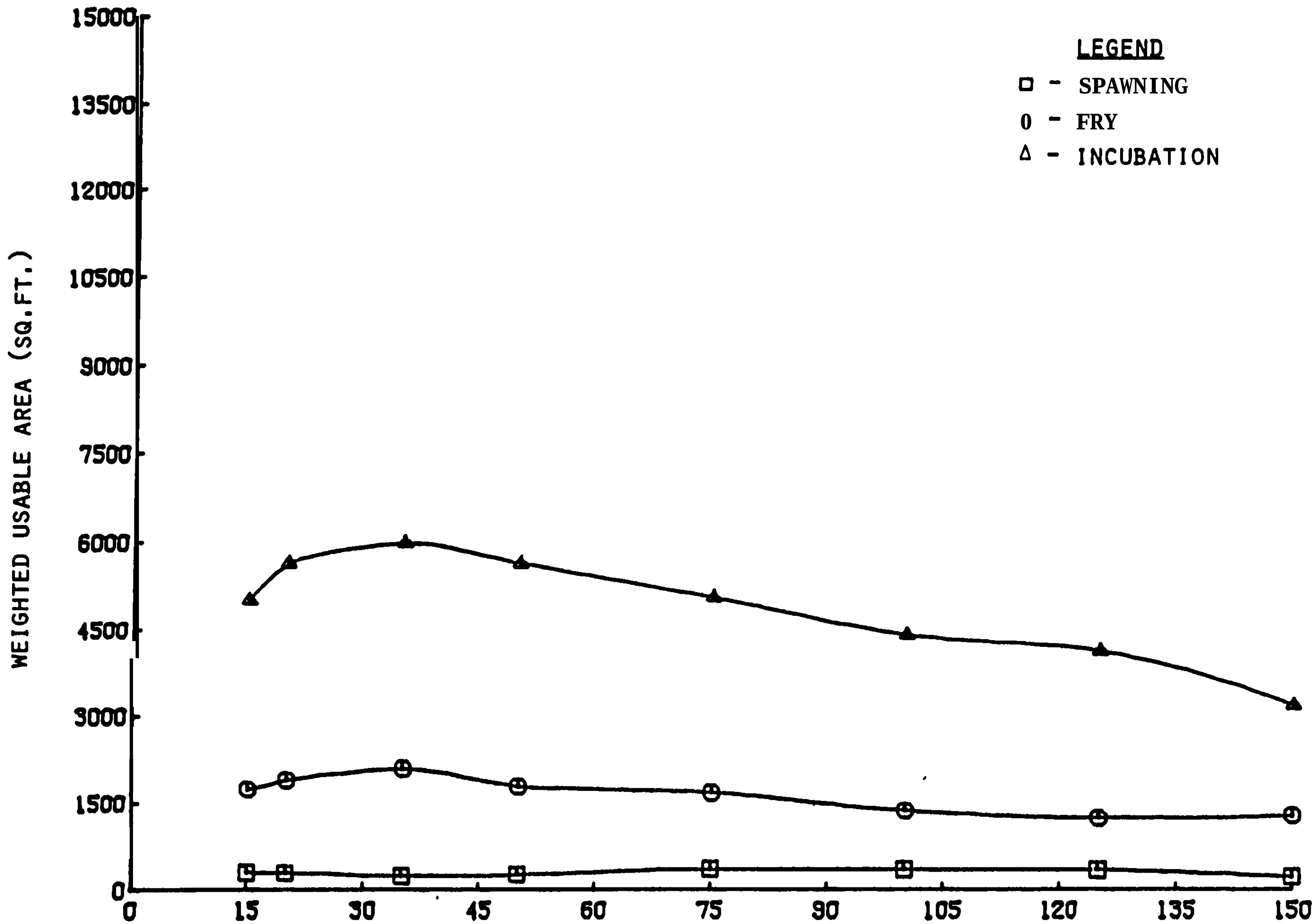
MILL CREEK M-1

STEELHEAD (CLEARWATER, S = ,004)



MILL CREEK M-1

CHINOOK SALMON (CLEARWATER, S = ,004)



MILL CREEK M-1

COHO SALMON (CLEARWATER, S = ,004)

MILL CREEK (M-l)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.)
PER 1000 **FEET OF STREAM**

STEELHEAD

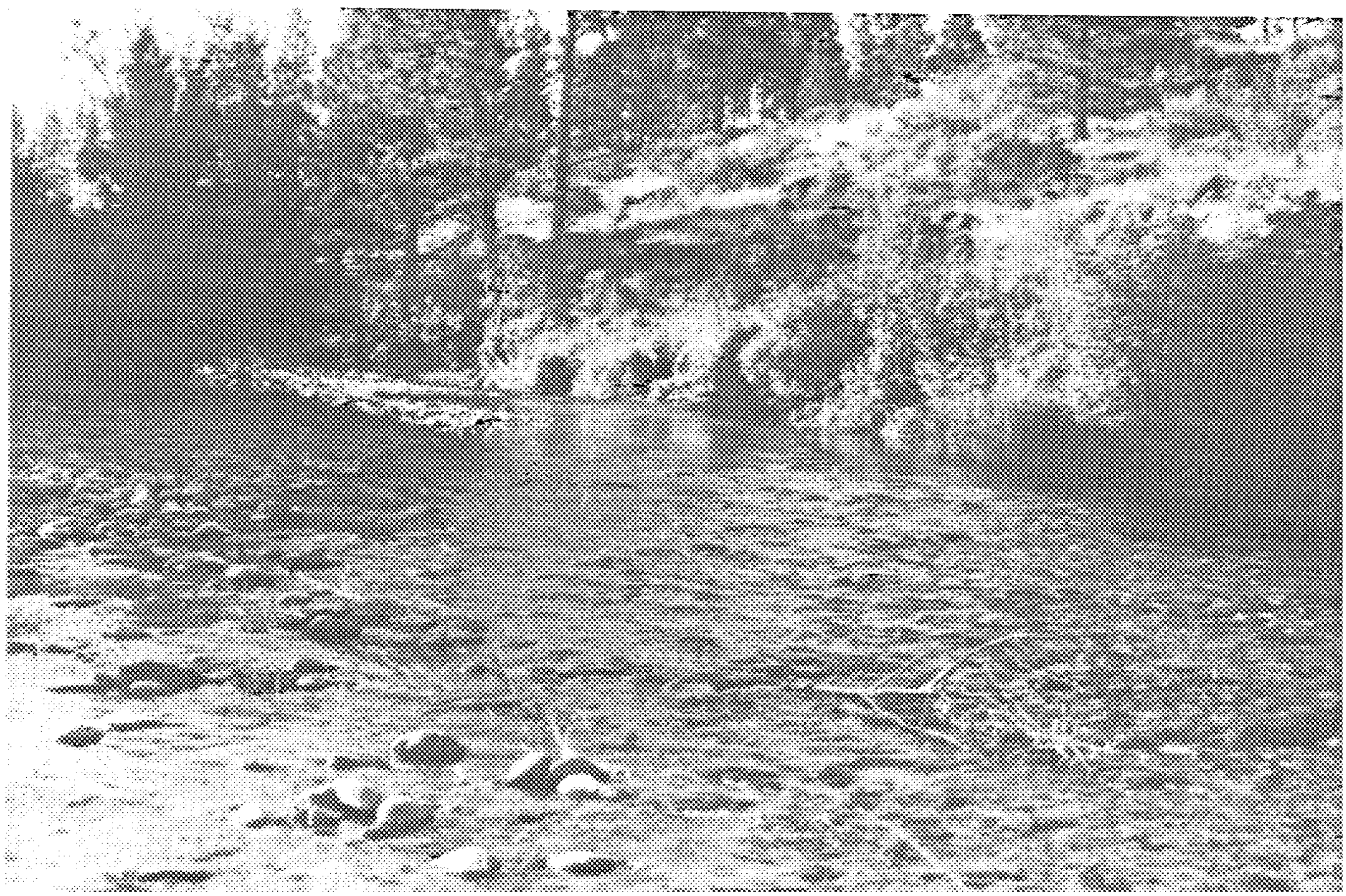
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
15	631	106	8826	9226	8722
20	1060	203	10312	9698	9872
35	1716	804	12063	9763	12392
50	1568	1182	12129	8484	13183
75	1298	1767	11286	7390	13664
100	1104	1678	10297	7131	13360
125	967	1690	9601	6397	12707
150	1101	1761	9149	5599	11269

CHINOOK SALMON

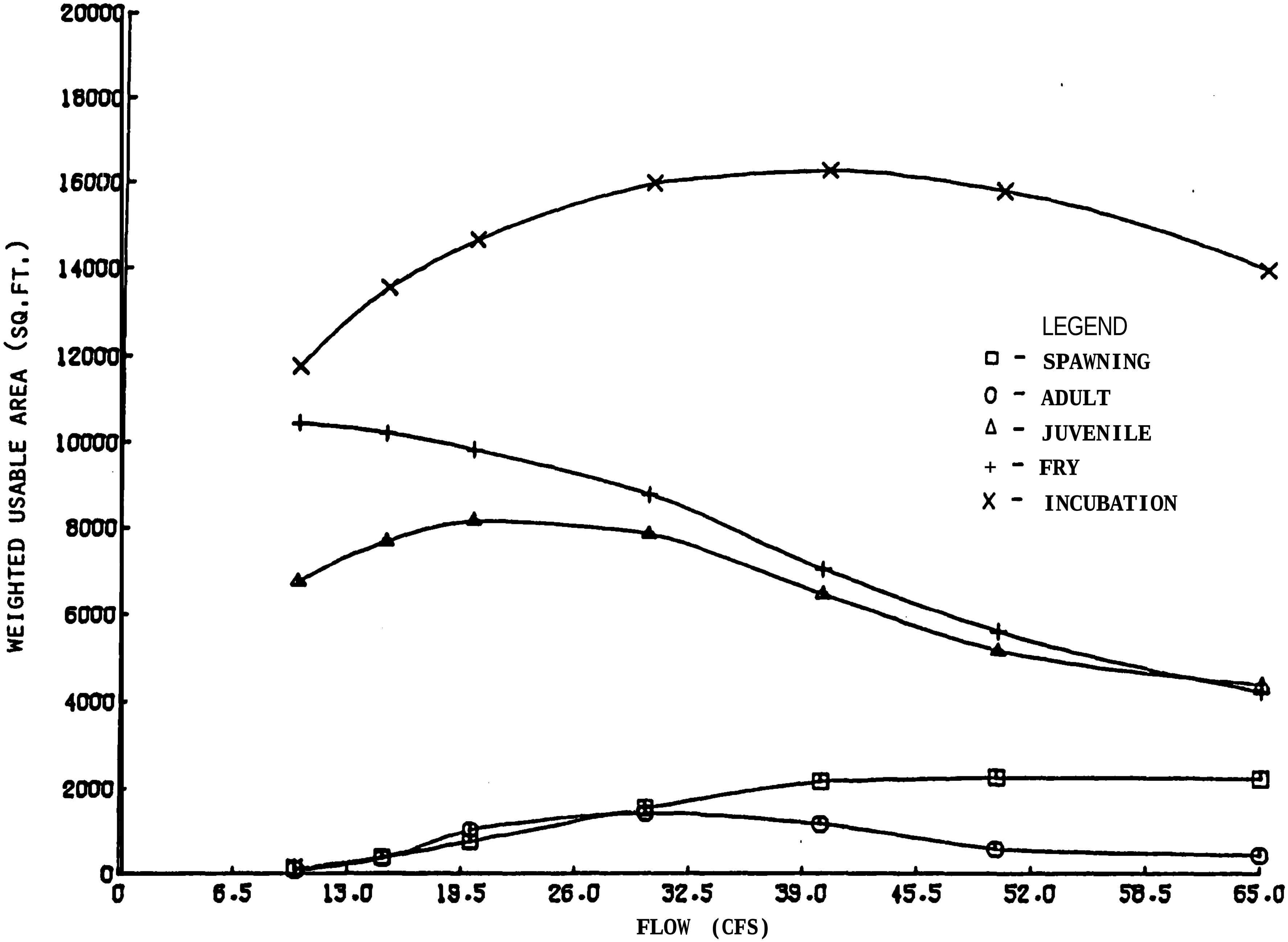
DISCHARGE	SPRING-SPANNING	FALL-SPAWNING	JUVENILE	INCUBATION
15	931	109	4820	6404
20	936	110	5790	7536
35	840	208	7386	9096
50	946	246	7335	9081
75	796	238	6572	8748
100	714	360	6106	7958
125	600	431	5267	7294
150	472	333	4590	6137

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
15	304	1745	5022
20	296	1903	5666
35	242	2092	6004
50	269	1787	5664
75	364	1683	5068
100	349	1364	4426
125	339	1229	4135
150	225	1277	3197

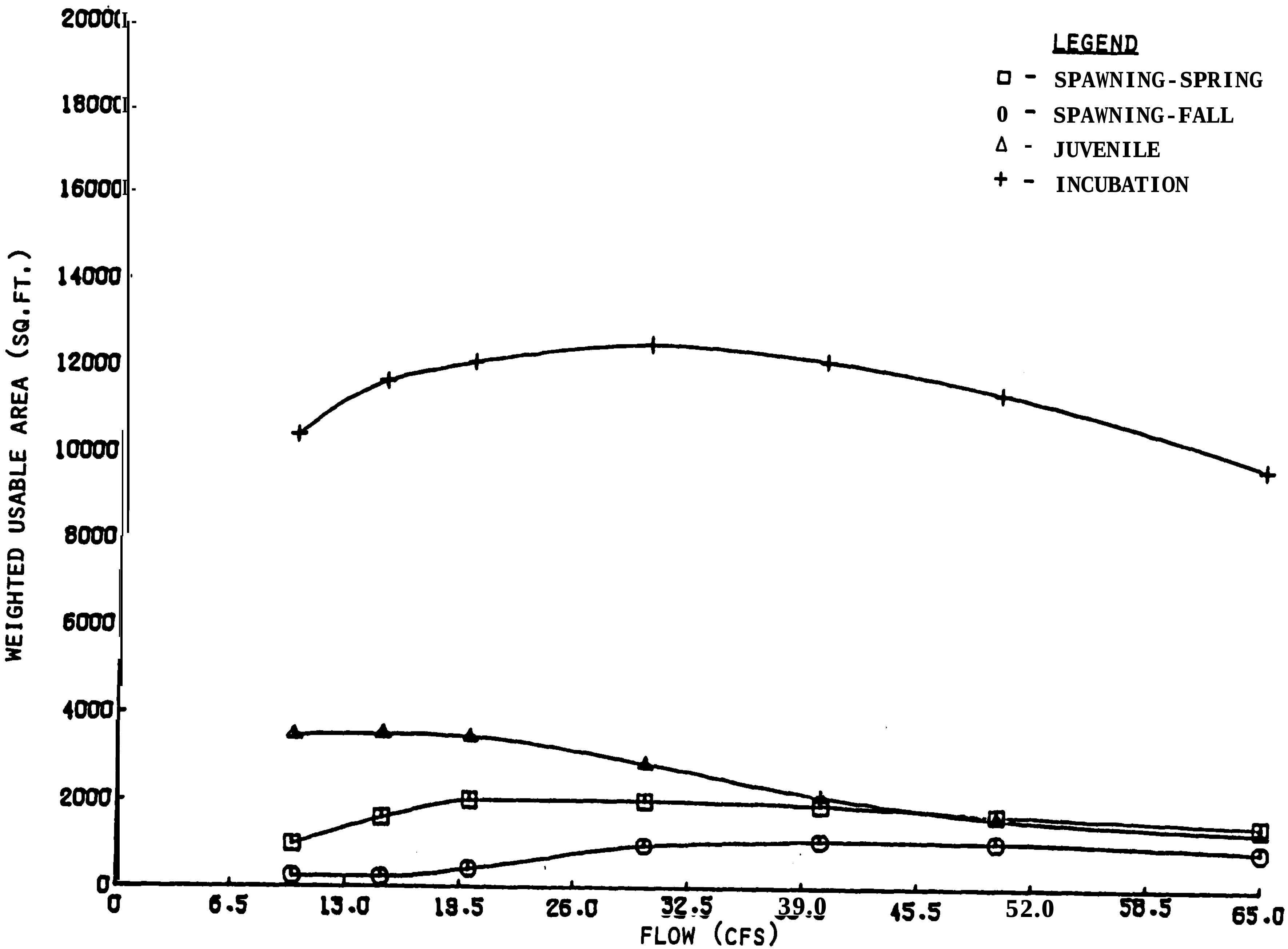


MILL CREEK M-2



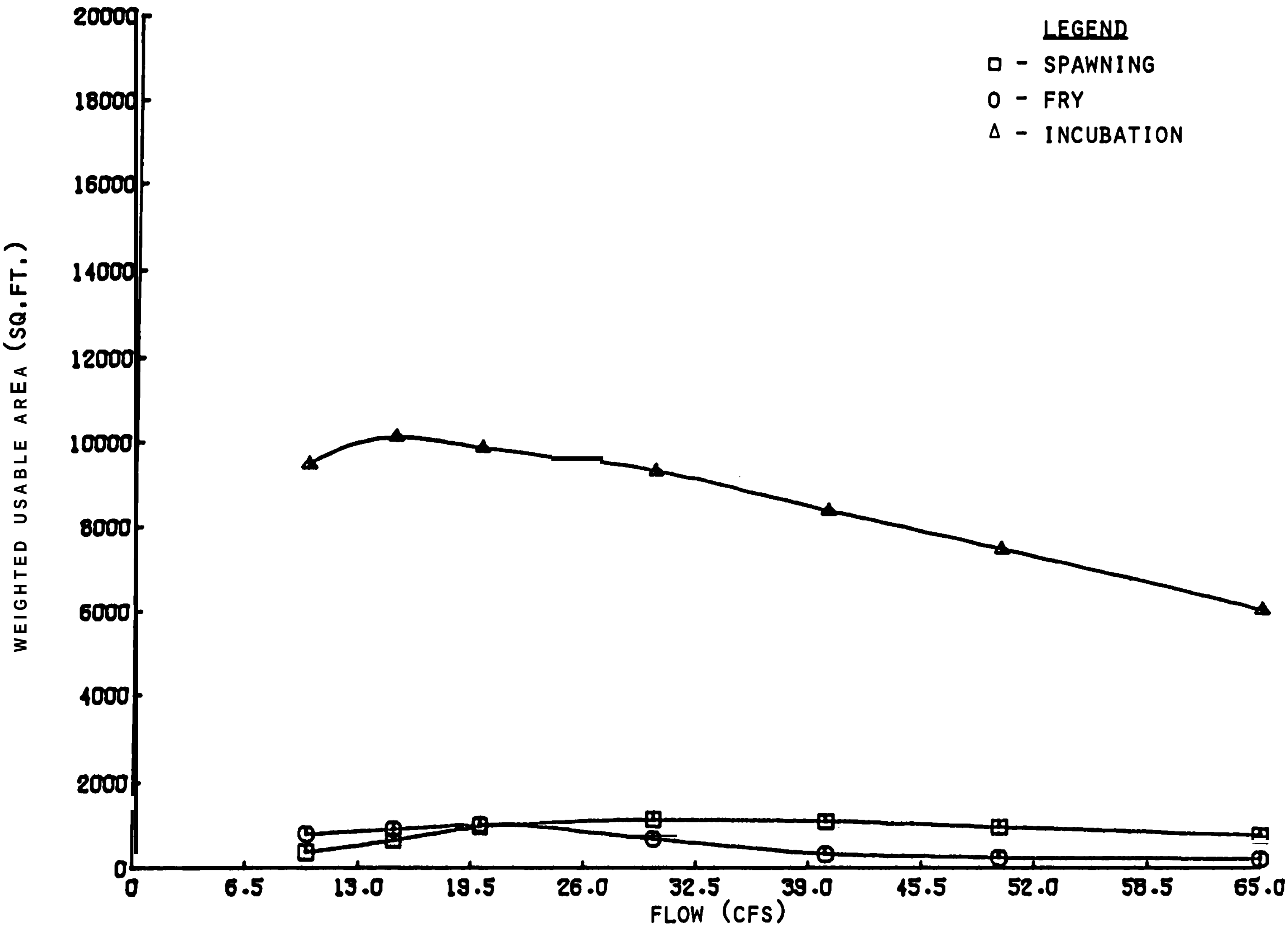
MILL CREEK M-2

STEELHEAD (CLEARWATER, S = ,004)



MILL CREEK M-2

CHINOOK SALMON (CLEARWATER, S = ,004)



MILL CREEK M-2

COHO SALMON (CLEARWATER, S = .004)

MILL CREEK (M-2)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 1000 FEET OF STREAM

STEELHEAD

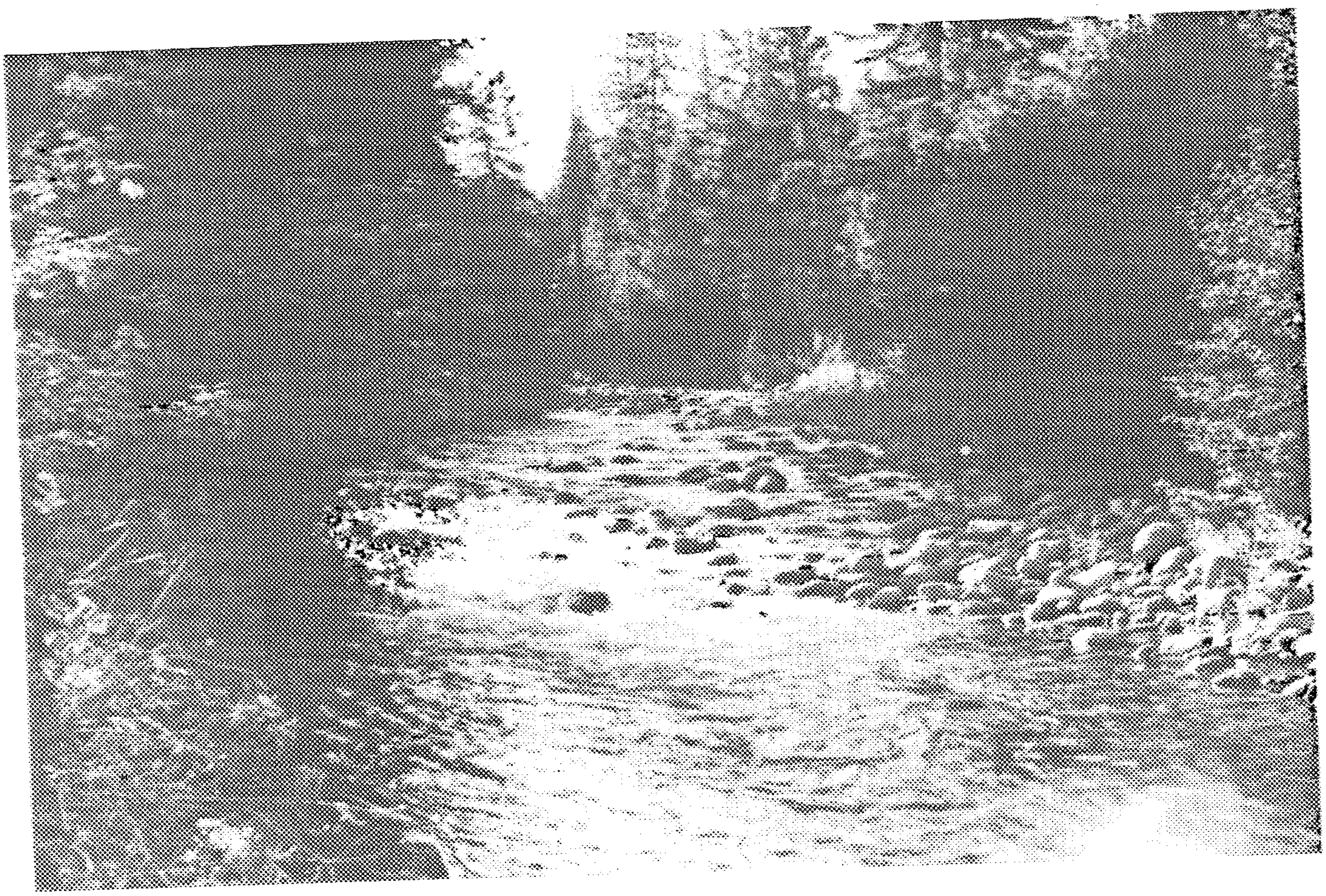
DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
10	151	98	6766	10468	11789
15	397	369	7703	10241	13574
20	768	1046	8173	9845	14687
30	1559	1438	7879	8804	16011
40	2185	1171	6481	7063	16321
50	2278	581	5178	5615	15844
65	2245	435	4396	4236	14028

CHINOOK SALMON

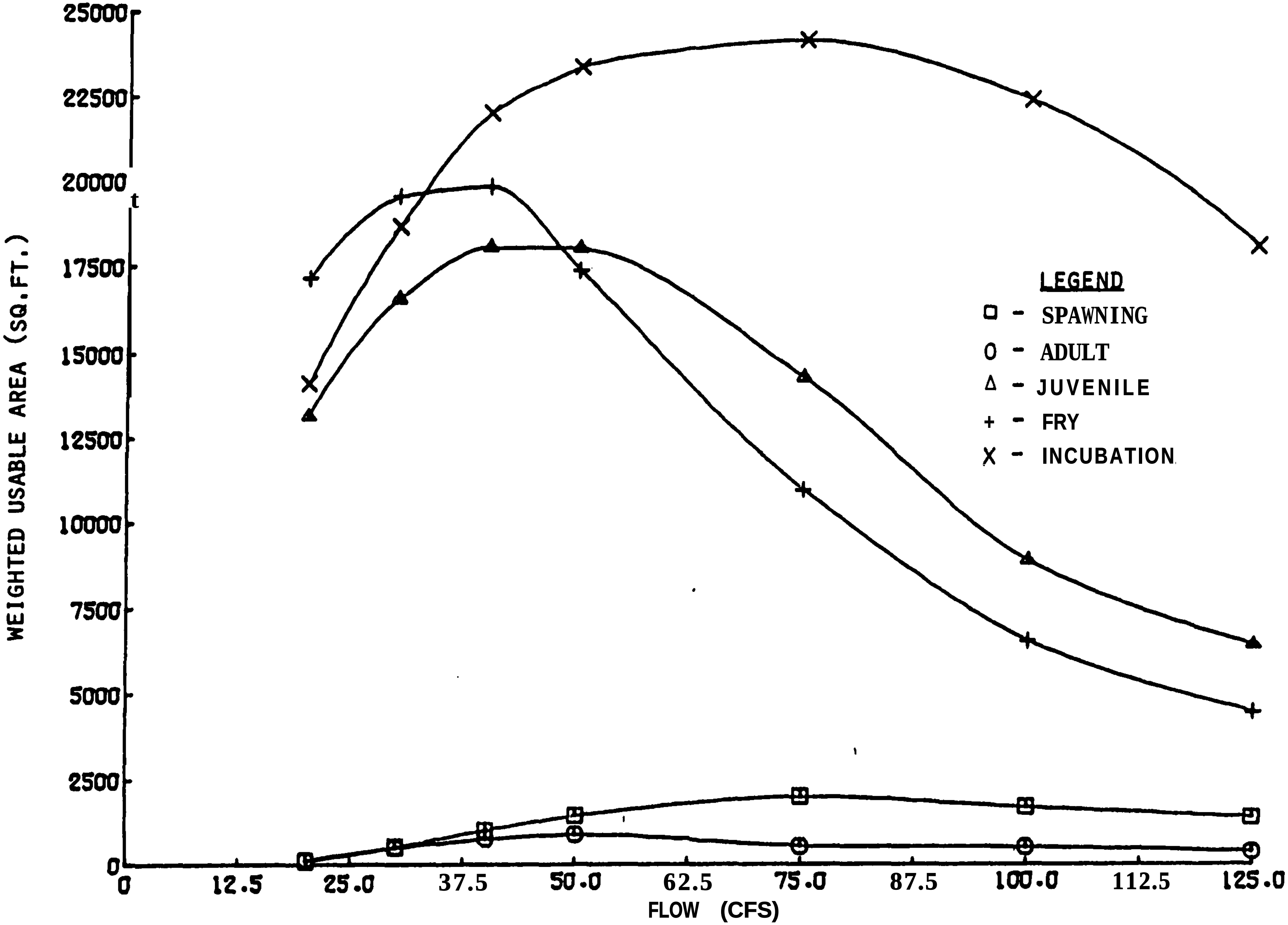
DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
10	984	254	3500	10399
15	1610	240	3535	11634
20	2028	436	3469	12086
30	2019	979	2867	12505
40	1922	1088	2120	12147
50	1714	1062	1615	11412
65	1483	885	1330	9722

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
10	391	827	9484
15	679	939	10121
20	1009	1053	9858
30	1169	700	9290
40	1119	344	8336
50	980	257	7423
65	788	222	5981

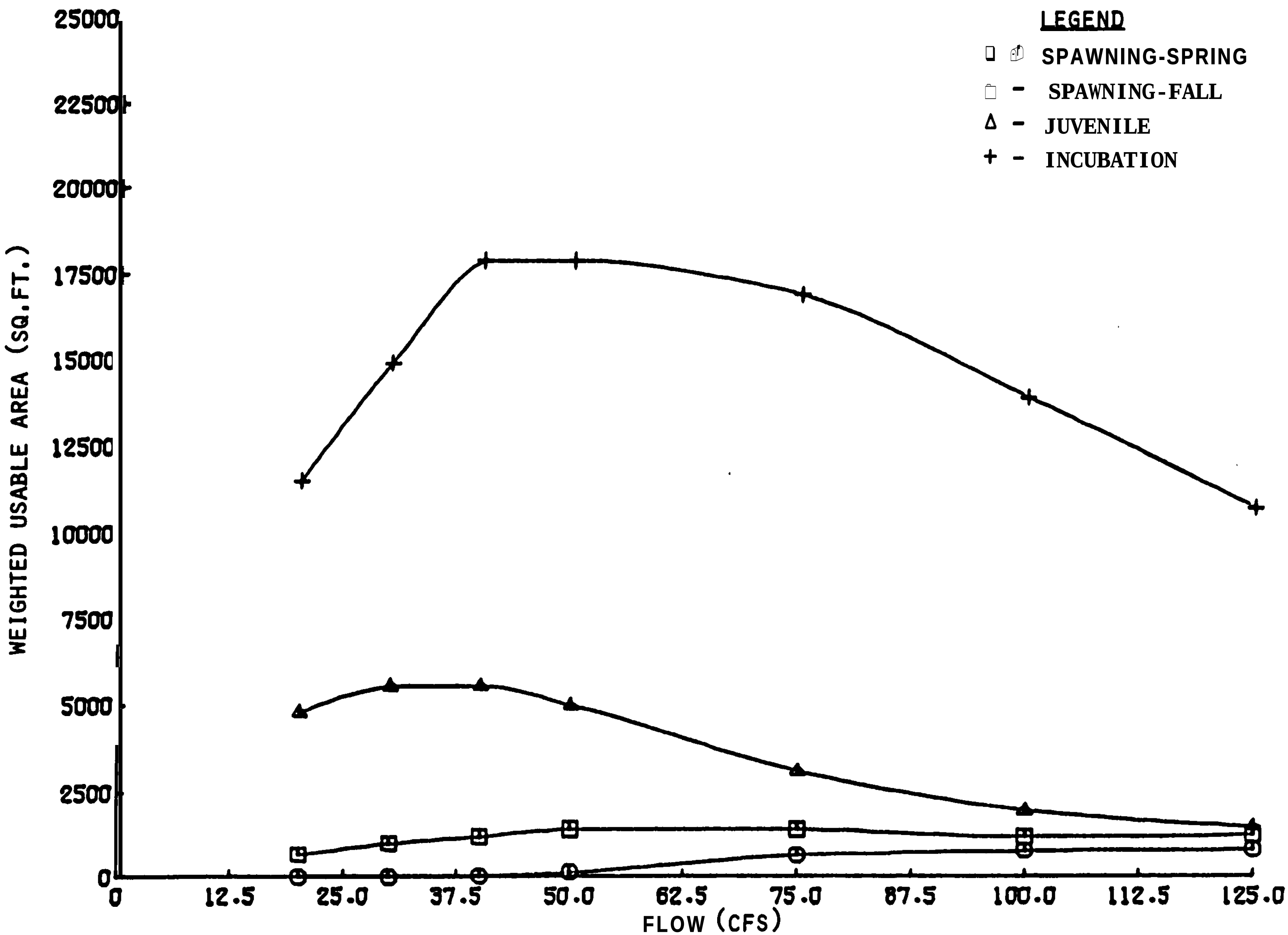


MILL CREEK M-3



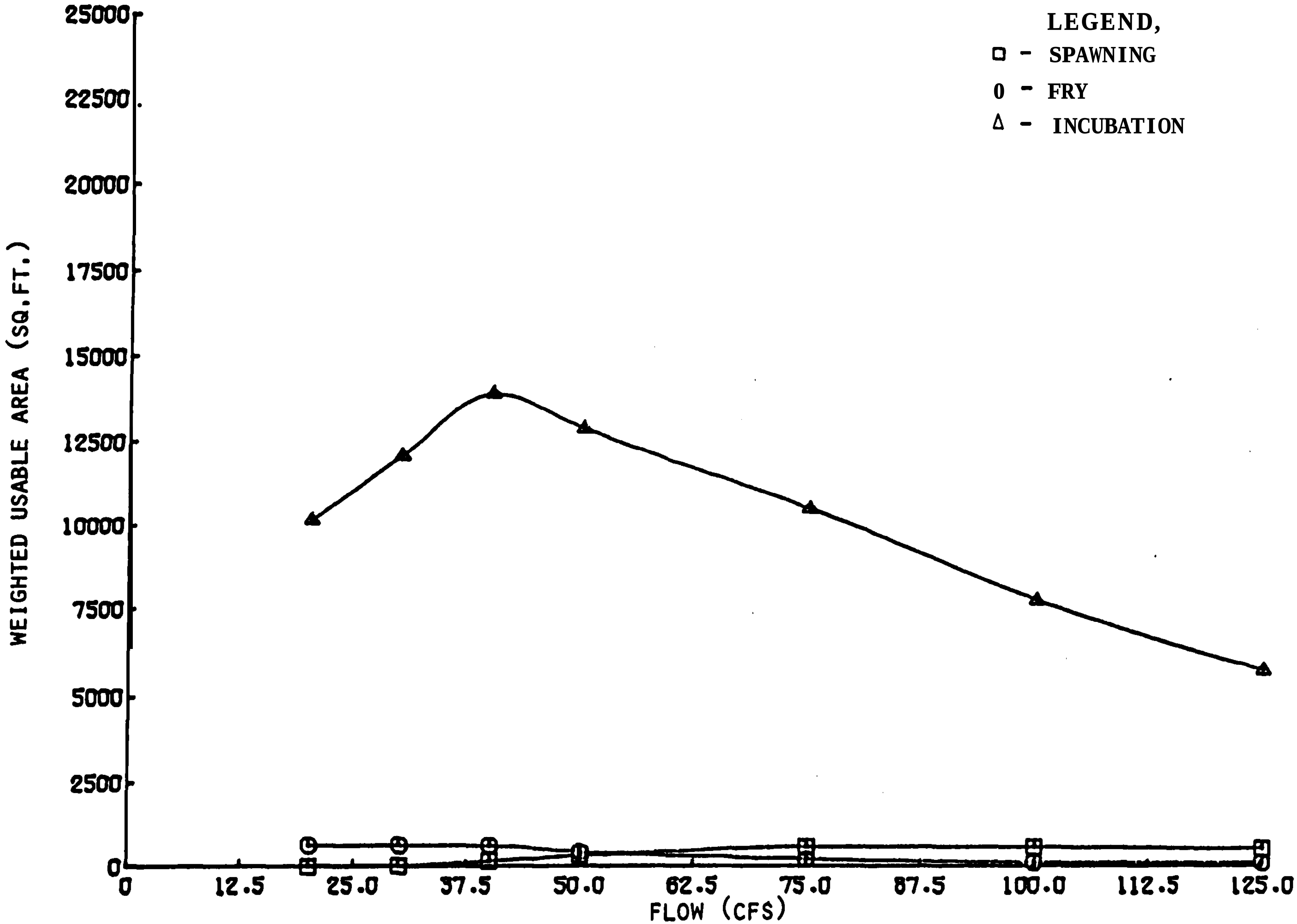
MILL CREEK M-3

STEELHEAD: (CLEARWATER, S = ,004)



MILL CREEK M-3

CHINOOK SALMON (CLEARWATER, S = ,004)



MILL CREEK M-3

COHO SALMON (CLEARWATER, S = ,004)

MILL CREEK (M-3)

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ. FT.) PER 1000 FEET OF STREAM

STEELHEAD

DISCHARGE	SPAWNING	ADULT	JUVENILE	FRY	INCUBATION
20	122	146	13211	17192	14169
30	531	507	16594	19567	18679
40	1026	769	18101	19864	22054
50	1463	895	18075	17422	23421
75	2018	551	14362	11020	24200
100	1708	517	8904	6596	22450
125	1409	392	6472	4478	18152

CHINOOK SALMON

DISCHARGE	SPRING-SPAWNING	FALL-SPAWNING	JUVENILE	INCUBATION
20	673		4811	11528
30	1016	10	5571	14916
40	1218	41	5574	17922
50	1427	146	5009	17923
75	1421	659	3117	16930
100	1194	783	1966	13937
125	1267	824	1480	10768

COHO SALMON

DISCHARGE	SPAWNING	FRY	INCUBATION
20	1	636	10155
30	33	642	12122
40	178	621	13932
50	340	443	12888
75	587	221	10490
100	568	131	7718
125	522	104	5715

OVERVIEW

Spring Chinook

Spawning Habitat

Spawning surveys for spring chinook salmon have been done by the Tribe and the USFWS since 1969. Table 3 shows the distribution of spawning effort in the drainage. Figure 6 illustrates the amount of spawning habitat available at each reach during optimum flows. Within the Warm Springs River spring chinook spawning is concentrated in the areas from below Bunchgrass Creek to about one mile below the Highway 26 bridge, this corresponds to homogenous stream sections represented by W-6, 7, and 8. Additional spawning takes place from just below Warm Springs NFH to Kah-Nee-Ta Village which is represented by study reach W-3. Spawning occurs from early to mid-September.

Table 3. Distribution of Spring Chinook Spawning Effort in the Warm Springs River and Tributaries.

	Warm Springs River	Beaver Creek	Mill Creek	Total #Redds
1969	78%	15%	8%	264
1970	69%	24%	7%	172
1971	88%	9%	3%	173
1972	77%	12%	0	87
1973	68%	26%	6%	584
1974	80%	14%	6%	216
1975	69%	20%	11%	808
1976	78%	14%	7%	1066
1977	85%	10%	5%	694
1978	79%	15%	6%	796
1979	71%	27%	2%	359
1980	76%	19%	5%	117
Mean	77%	17%	6%	

During the years 1978-1980 an average of 44% of the spawning activity took place in that area represented by W-8, 45% in W-7, 9% in W-6 and an additional 2% in the area represented by W-3.

The homogenous area represented by W-8 appears to be getting a dis-appropriately large share of the spawning effort if the optimum spawning habitat is compared to W-7 or W-6; however based on personal observation, the flows in W-8 appear to be very near optimum during the spawning period. Flows are relatively constant in this area most of the summer. The optimum flows for W-6 and W-7 just downstream are lower than that for W-8, and the present flow regime in these areas produces less than the maximum amount of habitat potentially available. Tables 4, 5, and 6 give the discharges producing the maximum amount of habitat within the drainage. Higher than optimum discharges probably occur in

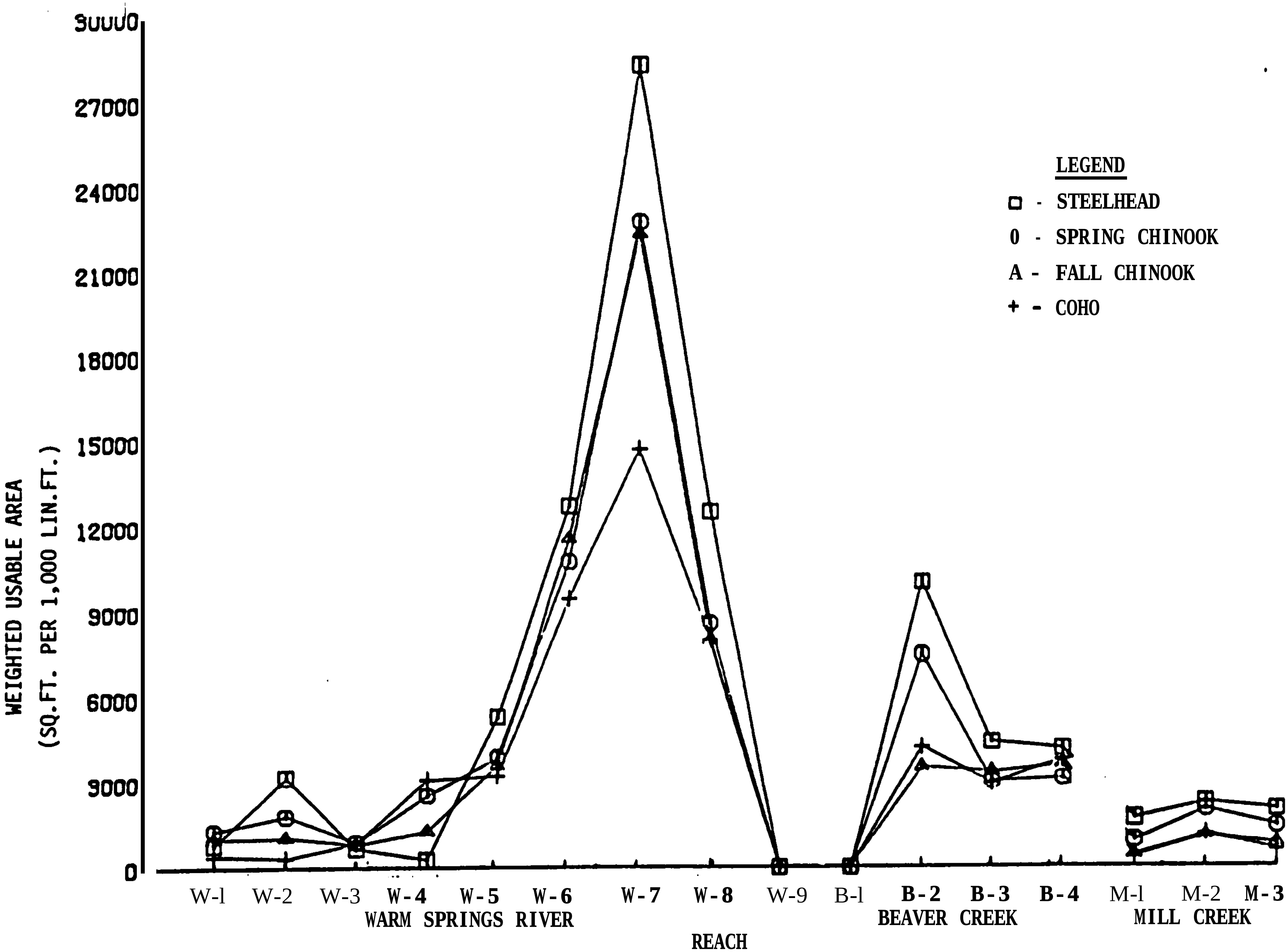


Figure 6. Potential spawning habitat at optimum flows.

Table 4. Discharges Providing Optimum Habitat for Anadromous Fish in the Warm Springs River.

STEELHEAD

Reach	Spawning	Adult	Juvenile
W-l	600	500	300
w-2	300	400	200
w-3	200	200	150
w-4	300	500	350
w-5	300	300	150
W-6	125	90	90
w-7	160	160	100
W-8	150	75	100
w-9	*	125	35

SPRING CHINOOK

Reach	Spawning	Adult	Juvenile
W-l	200		150
w-2	150		150
w-3	700		150
w-4	150		250
w-5	150		100
W-6	90		90
w-7	75		160
W-8	100		
w-9	*		35

FALL CHINOOK

Reach	Spawning	Adult	Juvenile
W-l	500		150
w-2	300		150
w-3	700		150
w-4	200		250
w-5	150		100
W-6	100		90
w-7	75		160
W-8	125		
w-9	*		3:

COHO

Reach	Spawning	Adult	Juvenile
W-l	300		-
w-2	150		-
w-3	400		-
w-4	150		-
w-5	100		-
W-6	90		-
w-7	60		-
W-8	100		-
w-9	*		-

* No spawning habitat available
- Lifestage data not provided by IFG model

Table 5. Optimum Flows for Anadromous Fish in Beaver Creek.

Reach	Sapwning	Adult	Juvenile
	STEELHEAD		
B-l	*	150	75
B-2	125	150	65
B-3	35	50	35
B-4	40	15	15
	SPRING CHINOOK		
B-l	*		100
B-2	50		80
B-3	20		15
B-4	25		15
	FALL CHINOOK		
B-1	*		
B-2	65		100 80
B-3	20		15
B-4	25		15
	COHO		
B-l	*		
B-2	50		
B-3	20		
B-4	25		

* No spawning area available
- Lifestage data not provided by IFG model

Table 6. Optimum Flows for Anadromous Fish in Mill Creek.

Reach	Spawning	Adult	Juvenile
	STEELHEAD		
M-1	35	75	50
M-2	50	30	20
M-3	75	50	40
	SPRING CHINOOK		
M-l	50		35
M-2	20		15
M-3	50		40
	FALL CHINOOK		
M-l	125		35
M-2	40		15
M-3	125		40
	COHO		
M-l	75		
M-2	30		
M-3	75		

- Lifestage data not provided by IFG model

tbese areas during the spawning period which would have the effect of reducing the available habitat. Table 7 gives an indication of the type of flow regimes seen during the study period in these areas. Water temperatures in all three areas are probably quite similar during the spawning period, and well within the preferred range fqr spring chinook spawning. Table 8 gives the approximate spawning times for anadromous fish in the system.

Table 8. Approximate Spawning Periods for Anadromous Fish in the Warm Springs River.

STEELHEAD	→	Mid February	-	Mid May
SPRING CHINOOK	→	Mid August	-	Late September
FALL CHINOOK*	→	October	-	End of November
COHO	→	October	-	End of November

* Not presently occurring in the drainage

The area represented by study reach W-3 receives more spawning activity than expected based on its optimum habitat compared to the other homogenous sections. The flows actually occurring during the spawning period are actually much less than optimum for this area which further reduces the spawning habitat below that of any representative area except W-9. The reasons for the use of this area when other more suitable areas are available are unclear, however it appears that these fish are late arriving and are ready to spawn. The barrier dam and fish ladder at WSNFH may be contributing to the spawning use in this area by concentrating their numbers below the hatchery.

Some spring chinook spawning habitat occurs in the other representative areas in the Warm Springs River but little spawning occurs there.

Spawning in Beaver Creek occurs principally in the areas represented by reaches B-2 and B-3. B-l represents an area where spawning has occurred in some years. The model calculated that no spawning habitat is available in this area while incubation habitat is present. This may indicate that the depths or velocities over the spawning gravels are inadequate. Past observations of this area have revealed few spawning areas most of which were shallow and prone to siltation. The upper area of Beaver Creek (represented by B-4) is an area unutilized by spring chinook that has as much potential as heavily used areas downstream. The basic reason for the lack of spawning activity in this section is primarily due to a series of beaver dams which block access to it.

Table 7. Discharges at Study Reaches During Sampling Periods.

	Low Flow		Medium Flow		High Flow	
Reach	Date	Discharge(cfs)	Date	Discharge(cfs)	Date	Discharge(cfs)
W-1	11/1	256	6/4	338	3/10	760
W-2	10/30	241	6/5	350	3/5	768
W-3	10/25	276	6/6	321	3/6	720
W-4	9/18	227	6/3	329	3/12	602
W-5	9/17	181	6/2	266	3/11	412
W-6	10/21	119	5/12	195	3/3	311
W-7	10/31	102	3/7	196	4/22	245
W-8	8/2	96	5/21	109	4/4	115
W-9	10/31	61	3/10	86	4/22	119
B-1	5/22	77	-	-	3/11	190
B-2	10/29	39	5/13	89	3/7	160
B-3	10/26	15	5/13	56	3/8	104
B-4	10/24	15	3/3	94	4/21	131
M-1	8/19	18	5/21	76	3/6	104
M-2	8/19	21	5/20	41*	3/5	59*
M-3	11/2	35	3/8	74	4/23	90

* An additional 18 cfs was being diverted just above this reach during these periods.

In the past, spring chinook spawning in Mill Creek was restricted to the area below Potter's Pond. This area is represented by reach M-2, and has the most spawning habitat in the stream. Discharges in this area during the spawning period appear to be near optimum. Spawning areas in the lower canyon (M-1) are limited. Some spawning now takes place above Potter's Pond since the dam washed out, but the falls below Old Mill Camp appear to be a barrier to spring chinook. Potential spawning habitat as indicated by reach M-3 is located both above and below the falls.

Juvenile Rearing

Rearing habitat for juvenile spring chinook is available in all the homogenous sections with that in the lower drainages of all waters generally having the most potential at optimum flows. Figure 7 illustrates the potential habitat at optimum flows in the system. In most cases the optimum juvenile habitat occurs at flows below those that are actually occurring. This is demonstrated by comparing the actual flow occurring at the USGS gaging station or the Warm Springs River (Figure 5) with the optimum flow required for juvenile rearing at reach W-2.

STEELHEAD

Steelhead have the most potential habitat at optimum flows for the anadromous fish studied in this report. Considerable spawning habitat occurs in most reaches in the drainage. Figure 6 shows the habitat available at optimum spawning flows. The only reaches where optimum steelhead spawning habitat is lower than the other species is in those sections represented by study reaches W-1, W-3 and W-4. The only areas where no spawning habitat is available are represented by study reaches W-9 and B-1.

Optimum spawning habitat in Beaver Creek appears to be greatest in the B-2 area. Mill Creek offers nearly equal optimum spawning habitat in all three areas although the section below Potter's Pond has slightly more than the others.

At optimum flows the potential juvenile rearing habitat is abundant throughout most of the system. The main exceptions to this are those areas represented by W-9, B-3 and B-4.

Steelhead presently spawn in the Warm Springs River, Mill Creek and Beaver Creek.

FALL CHINOOK

The potential spawning habitat at optimum flows for fall chinook is as good as that for spring chinook in almost all sections of the Warm Springs River. The section of Beaver Creek represented by B-2 offers much less potential for fall chinook than spring chinook although fall chinook have slightly more potential habitat at optimum flows. Mill Creek offers very little spawning habitat for fall chinook because of the low flows occurring in the fall when a much higher flow is needed for maximum habitat.

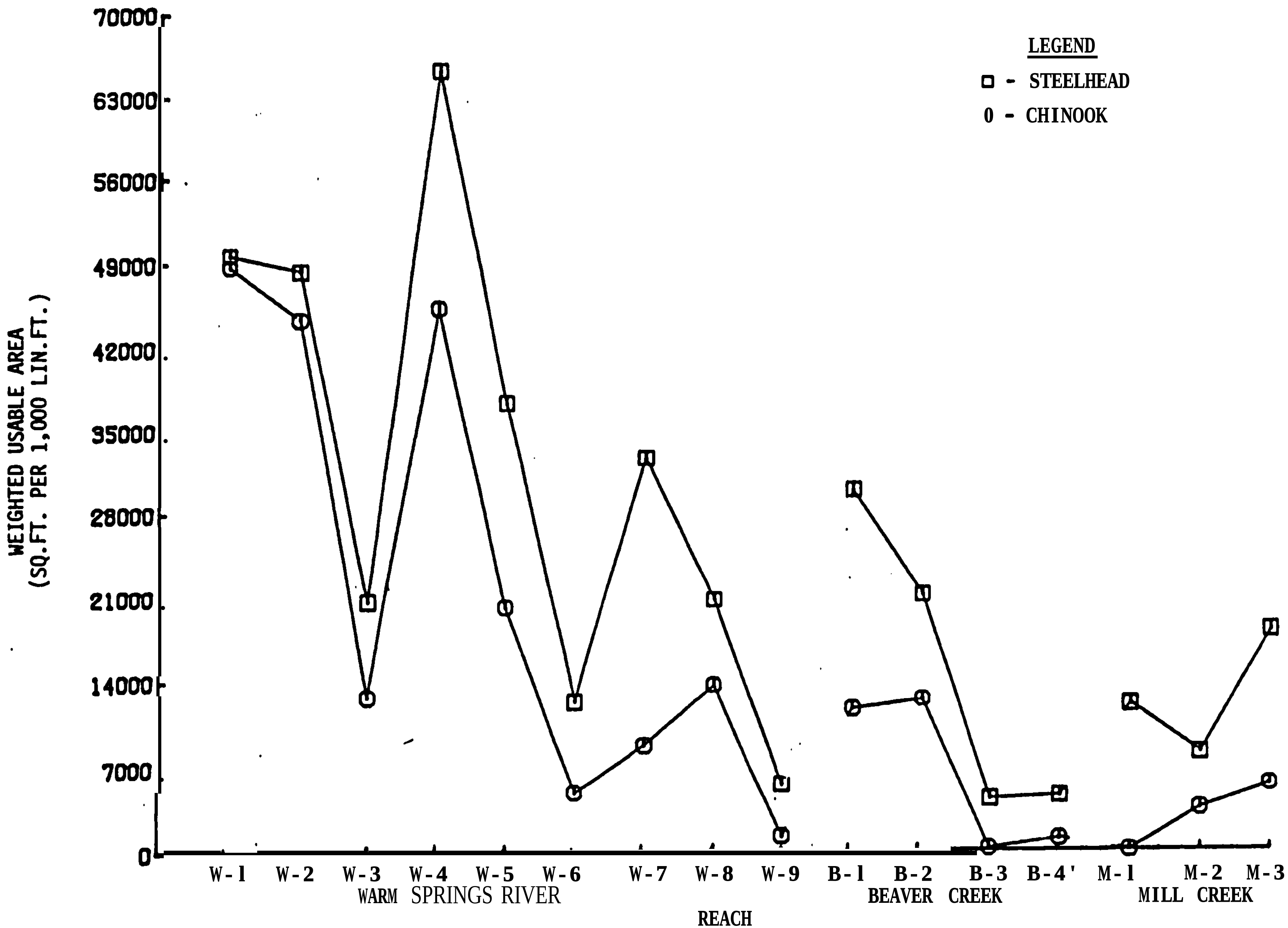


Figure 7. Potential juvenile rearing habitat at optimum flows.

COHO

Coho have spawning habitat at optimum flows in most sections. The greatest potential habitat occurs in the sections represented by W-6, W-7, and W-8. Discharges in these areas at spawning time are probably near optimum. Beaver Creek reaches B-2, B-3, and B-4 all have spawning habitat as well as flows that are probably near optimum. A remnant run of coho is thought to be presently spawning in the B-2 area. some spawning habitat exists for coho in Mill Creek with most being in the middle section.

POTENTIAL FOR ENHANCEMENT

Warm Springs River

The Warm Springs River is a free flowing stream that supports significant runs of spring chinook, steelhead, and some coho. This resource is important not only to the Warm Springs Tribe but also to the whole lower Columbia River basin. Because of this importance, the protection and enhancement of this run is essential.

Flow manipulation within the system would probably be quite difficult and provide little gain. The areas having the bulk of the spawning habitat are at near optimum flows for the species presently utilizing the system. Any changes made in flows to increase habitat for one species will most likely be detrimental to another, trade-offs would have to occur.

Steelhead have the most potential spawning and rearing habitat in the drainage. Their present spawning activities are scattered throughout the drainage and there is probably much unutilized spawning habitat available. A greater utilization of the available spawning habitat by steelhead would not impact the spawning use by the other anadromous fish since steelhead are spring spawners. The juvenile rearing habitat would probably be the area of competition. Juvenile steelhead out plants to areas that are underutilized and having sufficient rearing potential could increase the system's steelhead runs. Identifying these areas for enhancement will require a better knowledge of where steelhead are currently spawning and such factors such as flow regimes and carrying capacity.

Spring chinook have been, and will probably continue to be, the main species of interest in the Warm Springs System. WArm Springs National Fish Hatchery is presently being operated with the goal of enhancing this run. Once hatchery adults begin returning, those numbers of fish beyond the needs of the hatchery will be added to the wild fish released to spawn naturally above the hatchery. Outplants of chinook juveniles into areas like those represented by W-6 and W-7 may result in adults returning to utilize the spawning habitat that presently is underutilized. Those areas offering abundant rearing habitat probably will give the most successful results following outplants.

Fall chinook have abundant spawning and rearing potential during optimum flows in the upper Warm Springs River, but little spawning habitat exists even at optimum flows in the lower river. At the present time spring chinook are the preferred species in this drainage due to the excellent condition of the returning adults. They are more highly prized than fall chinook in the subsistance fishery. It's quite probable that the establishment of fall chinook in the drainage may come at the expense of the other more highly valued anadromous species. Competition may exist for spawning and rearing habitat and other needs where species requirements overlap.

Coho have somewhat less potential habitat in the Warm Springs River than the other species examined but they have proven themselves capable of maintaining a population within the drainage. Once again the enhancement of this specie might come at the expense of other species.

Tributaries

Beaver Creek offers more potential habitat than Mill Creek. The areas within Beaver Creek canyon offer more spawning habitat than previously thought. Much of the habitat is relatively unused. Additional potential spawning habitat exists in the upper areas but much of this is not accessible to adult fish because of numerous beaver dams. Steelhead may be able to ascend beyond these dams because they spawn at higher flows in the spring; but the other species arrive during low water levels in the fall, they probably could not pass the dams. The enhancement of these species in Beaver Creek would require removal of the dams.

Mill Creek anadromous fish runs could be increased with several improvements. The area represented by study reach M-3 is for the most part unutilized by anadromous fish. Strawberry Falls, which is about a mile above Potter's Pond is a barrier to returning adults. Some steelhead may be able to ascent the falls during high spring flows but low fall flows make it impassible to fall spawning fish. Passage improvements at the falls are needed to realize the habitat potential. Outplants of juveniles into this area could be successful because of the increased rearing potential of this area over that of lower Mill Creek. The irrigation diversion one-half mile above Old Mill Camp would need to be screened to prevent the loss of juveniles moving downstream. The water diverted above Old Mill Camp would improve late summer and fall passage conditions in lower Mill Creek if it remained in the main stream channel.

Juvenile rearing habitat in upper Beaver and Mill Creeks could probably be enhanced by the addition of structures that would reduce velocities and increase depths. Log weins or wing deflectors installed within the stream might help to increase smolt production in these areas.

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